DATA TRANSLATION

UM-21336-C

DT9816
User's Manual

Third Edition
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Radio and Television Interference

This equipment has been tested and found to comply with CISPR EN55022 Class A, and EN50082-1 (CE) requirements and also with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Changes or modifications to this equipment not expressly approved by Data Translation could void your authority to operate the equipment under Part 15 of the FCC Rules.

Note: This product was verified to meet FCC requirements under test conditions that included use of shielded cables and connectors between system components. It is important that you use shielded cables and connectors to reduce the possibility of causing interference to radio, television, and other electronic devices.

Canadian Department of Communications Statement

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la class A prescrites dans le Règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada.

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About this Manual

The first part of this manual describes how to install and set up your DT9816 module and software, and verify that your module is working properly.

The second part of this manual describes the features of the DT9816 module and device driver, and how to program these modules using the DT-Open Layers™ software. It also provides troubleshooting information. Unless otherwise specified, all references to the DT9816 module refer to both the DT9816 and DT9816-A model numbers.

Intended Audience

This document is intended for engineers, scientists, technicians, or others responsible for using and/or programming the DT9816 module for analog input, digital I/O, or counter/timer operations in the Microsoft® Windows® 2000 or Windows XP operating system. It is assumed that you have some familiarity with data acquisition principles and that you understand your application.

How this Manual is Organized

This manual is organized as follows:

- Chapter 1, "Overview," describes the major features of the DT9816 module, as well as the supported software and accessories for the module.
- Chapter 2, "Preparing to Use a Module," describes how to unpack the module, check the system requirements, and install the software.
- Chapter 3, "Setting Up and Installing the Module," describes how to install the module and how to configure the device driver.

- Chapter 4, "Wiring Signals to the Module," describes how to wire signals to the module.
- Chapter 5, "Verifying the Operation of a Module," describes how to verify the operation of the module with the GO! application.
- Chapter 6, "Principles of Operation," describes all of the features of the DT9816 module and how to use them in your application.
- Chapter 7, "Supported Device Driver Capabilities," lists the supported subsystems and the associated capabilities accessible using the device driver for the DT9816 module.
- Chapter 8, "Programming Flowcharts," describes the processes you must follow to program the subsystems of a DT9816 module using DT-Open Layers-compliant software.
- Chapter 9, "Troubleshooting," provides information that you can use to resolve problems with a DT9816 module, should they occur.
- Appendix A, "Specifications," lists the specifications of the DT9816 module.
- Appendix B, "Screw Terminal Assignments," shows the screw terminal assignments of the DT9816 module.
- Appendix C, "Reading from or Writing to the Digital Registers," describes how to access the module's registers directly.
- An index completes this manual.

Conventions Used in this Manual

The following conventions are used in this manual:

- Notes provide useful information or information that requires special emphasis, cautions provide information to help you avoid losing data or damaging your equipment, and warnings provide information to help you avoid catastrophic damage to yourself or your equipment.
- Items that you select or type are shown in **bold**.

Related Information

Refer to the following documents for more information on using the DT9816 module:

- *Benefits of the Universal Serial Bus for Data Acquisition.* This white paper describes why USB is an attractive alternative for data acquisition. It is available on the Data Translation web site (www.datatranslation.com).
- *DT Measure Foundry Getting Started Manual* (UM-19298) and online help. These documents describe how to use DT Measure Foundry™ to build drag-and-drop test and measurement applications for Data Translation® data acquisition devices without programming.
- *DataAcq SDK User's Manual* (UM-18326). For programmers who are developing their own application programs using the Microsoft C compiler, this manual describes how to use the DT-Open Layers DataAcq SDK™ to access the capabilities of Data Translation data acquisition devices.
- *DTx-EZ Getting Started Manual* (UM-15428). This manual describes how to use the ActiveX controls provided in DTx-EZ™ to access the capabilities of Data Translation data acquisition devices in Microsoft Visual Basic® or Visual C++®.

- *DT-LV Link Getting Started Manual* (UM-15790). This manual describes how to use DT-LV Link™ with the LabVIEW™ graphical programming language to access the capabilities of Data Translation data acquisition devices.
- *DAQ Adaptor for MATLAB* (UM-22024). This document describes how to use Data Translation's DAQ Adaptor to provide an interface between the MATLAB Data Acquisition subsystem from The MathWorks and Data Translation's DT-Open Layers architecture.
- Microsoft Windows 2000 or Windows XP documentation.
- USB web site (http://www.usb.org).

Where To Get Help

Should you run into problems installing or using a DT9816 module, the Data Translation Technical Support Department is available to provide technical assistance. Refer to Chapter 9 for more information. If you are outside the United States or Canada, call your local distributor, whose number is listed on Data Translation's web site (www.datatranslation.com).

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Key Hardware Features

The DT9816 module is part of the ECONseries of economy, multifunction mini-instruments. Table 1 lists the key features of the module.

Table 1: Key Features of the DT9816 Module

Module	Analog Inputs	Analog Input Resolution	I/O Range	Analog Input Sample Rate	Digital I/O	C/T
DT9816	6 SE	16-bit	±10 V or ± 5 V	50 kS/s per channel	8 in/ 8 out	1
DT9816-A	6 SE	16-bit	±10 V or ± 5 V	150 kS/s per channel[a]	8 in/ 8 out	1

a. Actual maximum is 153.846 kHz. If you use the olDaSetClockFrequency function to set 150 kHz, the olDaGetClockFrequency function will not return the true value (153.846 kHz) until after you invoke the olDaConfig function.

The DT9816 is a low-power device (less than 100 mA draw).

Simultaneous Analog Inputs

The DT9816 module features six independent, 16-bit, successive-approximation A/D converters with track-and-hold circuitry. Each converter uses a common clock and trigger for simultaneous sampling of all six analog input signals at up to 50 kHz per channel (DT9816) or up to 150 kHz per channel (DT9816-A). All channels in the channel-gain list are read simultaneously on a single pulse of the internal clock.

The DT9816 module provides gains of 1 and 2, for effective full-scale input signal ranges of ±10 V and ±5 V.

Counter/Timer Channel

The DT9816 module supports one 16-bit counter/timer channel. This counter/timer allows you to perform event counting, frequency measurement, and continuous pulse output (rate generation) operations.

Clocks and Triggers

The DT9816 modules supports an internal trigger and clock or an external trigger and clock.

Use the internal trigger to start an analog input operation based on a software command, or use the external trigger to start an analog input operation based on an external event.

Use the external clock signal to pace an analog input operation at a rate not available with the internal clock or when you want to pace at uneven intervals.

Supported Software

The following software is available for use with the DT9816 module, and is provided on the ECON CD:

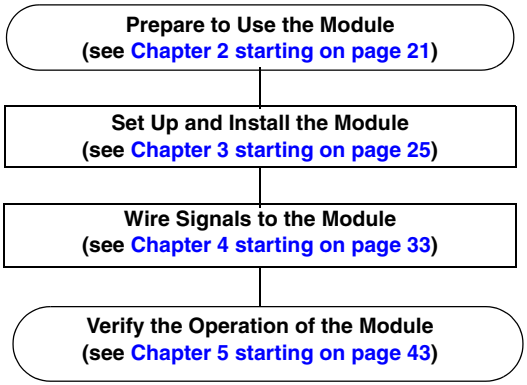
- **Device Driver** – The DT9816 Device Driver allows you to use a DT9816 module with any of the supported software packages or utilities. Refer to Chapter 2 for more information on loading the device driver.
- **GO! application** –The GO! application provides a quick way to measure and control data from a DT9816 module right out of the box. The following instrument views make acquiring data and controlling signals easy: oscilloscope, chart recorder, file viewer, digital voltmeter, digital input, digital output, frequency counter,

and rate generator. Refer to Chapter 5 for more information on this application.

- **DT Measure Foundry** – An evaluation version of this software is included or provided via a link on the ECON CD. DT Measure Foundry is drag-and-drop test and measurement application builder designed to give you top performance with ease-of-use development. Order the full development version of this software package to develop your own application using real hardware.
- **DataAcq SDK** – Use the Data Acq SDK if you want to develop your own application software for the DT9816 module using the Microsoft C compiler; the DataAcq SDK complies with the DT-Open Layers standard.
- **DTx-EZ** – Use this optional software package if you want to use ActiveX controls to access the capabilities of the DT9816 module using Microsoft Visual Basic or Visual C++; DTx-EZ complies with the DT-Open Layers standard.
- **DAQ Adaptor for MATLAB** – Data Translation's DAQ Adaptor provides an interface between the MATLAB Data Acquisition (DAQ) subsystem from The MathWorks and Data Translation's DT-Open Layers architecture.
- **DT-LV Link** – Use this optional software package if you want to use the LabVIEW graphical programming language to access the capabilities of the DT9816 module.

Getting Started Procedure

The flow diagram shown in Figure 1 illustrates the steps needed to get started using the DT9816 module. This diagram is repeated in each chapter; the shaded area in the diagram shows you where you are in the getting started procedure.


Prepare to Use the Module
(see Chapter 2 starting on page 21)
Set Up and Install the Module
(see Chapter 3 starting on page 25)
Wire Signals to the Module
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Verify the Operation of the Module
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Figure 1: Getting Started Flow Diagram

Part 1: Getting Started

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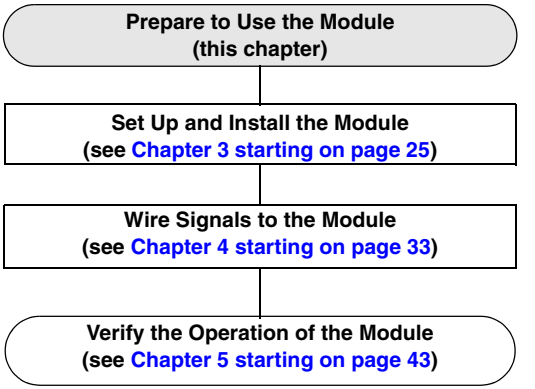
Prepare to Use the Module
(this chapter)
Set Up and Install the Module
(see Chapter 3 starting on page 25)
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(see Chapter 4 starting on page 33)
Verify the Operation of the Module
(see Chapter 5 starting on page 43)

Unpacking

Open the shipping box and verify that the following items are present:

- DT9816 module
- ECON CD
- USB cable

If an item is missing or damaged, contact Data Translation. If you are in the United States, call the Customer Service Department at (508) 481-3700. An application engineer will guide you through the appropriate steps for replacing missing or damaged items. If you are located outside the United States, call your local distributor (see Data Translation's web site (www.datatranslation.com) for contact information).

Once you have unpacked your module, check the system requirements, as described in the next section.

Checking the System Requirements

For reliable operation, your DT9816 module requires the following:

- Windows 2000 or Windows XP (Professional Edition) operating system.

  For USB Ver. 2.0 support, make sure that you install Service Pack 2 (for Windows XP) or Service Pack 4 (for Windows 2000). In addition, for some systems, you may have to disable standby mode. If you are not sure whether you are using USB Ver. 1.1 or Ver. 2.0, run the Open Layers Control Panel applet, described on page 27.

- One or more USB ports (Ver. 2.0 or Ver. 1.1). USB Ver. 2.0 is recommended for optimal performance.

- One CD-ROM drive.

Once you have verified that your system meets the system requirements, install the software, as described in the next section.

Installing the Software

To install the device driver, Data Acq SDK, DTx-EZ, and the GO! application, do the following:

1. Insert the ECON CD into your CD-ROM drive.
   If the software runs automatically (the default condition), continue with step 4.
2. If the software does not run automatically, click **Start** from the Task Bar, and then click **Run**.
   The Run dialog box appears.
3. In the Command Line edit box, enter **D:\Setup.Exe**.
   If your CD-ROM is not in drive D:, enter the letter of the drive where your CD-ROM is located. The welcome screen appears.
4. Click **Install Drivers and GO!**
5. Click **Install now!**
   The installation wizard appears.
6. Click **Next**.
   The wizard prompts you for the destination location.
7. Either change the directory path and/or name using **Browse** or accept the default directory (C:\Program Files\Data Translation), and then click **Next**.
8. Click **Next** to copy the files.
9. Click **Finish**.
10. If you want to install DT-LV Link, click **Install Additional Software**, click **Install now!** under the LabVIEW Link section, and follow the installation prompts.
11. When you have finished the installation process, click **Quit Installer**.

Continue with the instructions in Chapter 3 starting on page 25.

Setting Up and Installing the Module

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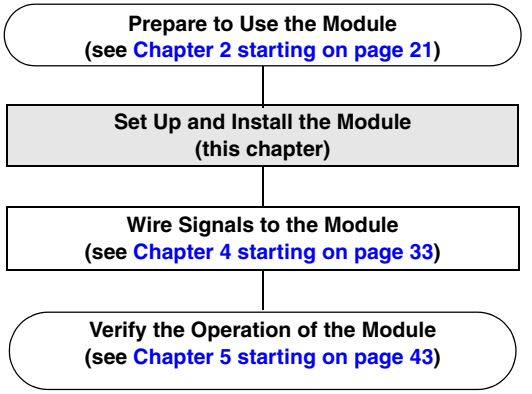
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(see Chapter 2 starting on page 21)
Set Up and Install the Module
(this chapter)
Wire Signals to the Module
(see Chapter 4 starting on page 33)
Verify the Operation of the Module
(see Chapter 5 starting on page 43)

Note: The DT9816 module is factory-calibrated and requires no further adjustment.

Attaching Modules to the Computer

This section describes how to attach a DT9816 module to the host computer.

Note: Most computers have several USB ports that allow direct connection to USB devices. If your application requires more DT9816 modules than you have USB ports for, you can expand the number of USB devices attached to a single USB port by using expansion hubs. For more information, refer to page 29.

You can unplug a module, and then plug it in again, if you wish, without causing damage. This process is called hot-swapping. Your application may take a few seconds to recognize a module once it is plugged back in.

Connecting Directly to the USB Ports

To connect DT9816 modules directly to the USB ports of your computer, do the following:

1. Attach one end of the USB cable to the USB port on the module.
2. Attach the other end of the USB cable to one of the USB ports on the host computer, as shown in Figure 2.
   The operating system automatically detects the USB module and starts the Found New Hardware wizard.

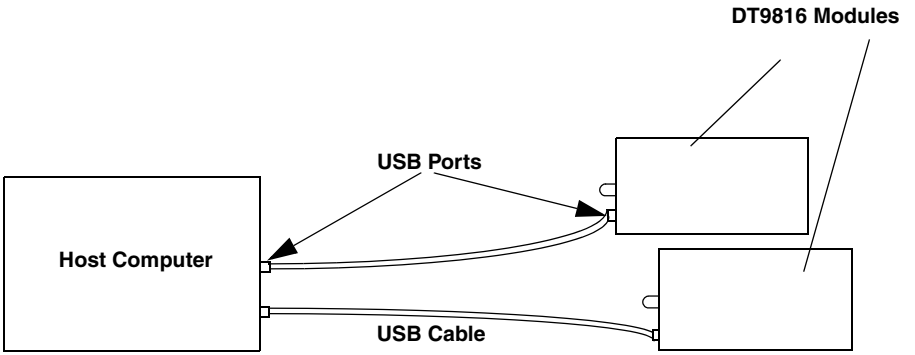

Figure 2: Attaching the Module to the Host Computer

3. Click **Next** and/or **Finish** in the wizard. Once the firmware is loaded, the wizard restarts to initiate the firmware to accept commands. Click **Next** and/or **Finish** again.
   If the power supply and module are attached correctly, the LED turns green.
4. Repeat the steps to attach another DT9816 module to the host computer, if desired.

Connecting to an Expansion Hub

Expansion hubs are powered by their own external power supply. Theoretically, you can connect up to five expansion hubs to a USB port on the host computer. However, the practical number of DT9816 modules that you can connect to a single USB port depends on the throughput you want to achieve. Each of the hubs supports up to four modules.

To connect multiple DT9816 modules to an expansion hub, do the following:

1. Attach one end of the USB cable to the module and the other end of the USB cable to an expansion hub.
2. Connect the power supply for the expansion hub to an external power supply.
3. Connect the expansion hub to the USB port on the host computer using another USB cable.
   The operating system automatically detects the USB module and starts the Found New Hardware wizard.
4. Click **Next** and/or **Finish** in the wizard. Once the firmware is loaded, the wizard restarts to initiate the firmware to accept commands. Click **Next** and/or **Finish** again.
   If the power supply and module are attached correctly, the LED turns green.
5. Repeat these steps until you have attached the number of expansion hubs (up to five) and modules (up to four per hub) that you require. Refer to Figure 3.
   The operating system automatically detects the USB devices as they are installed.

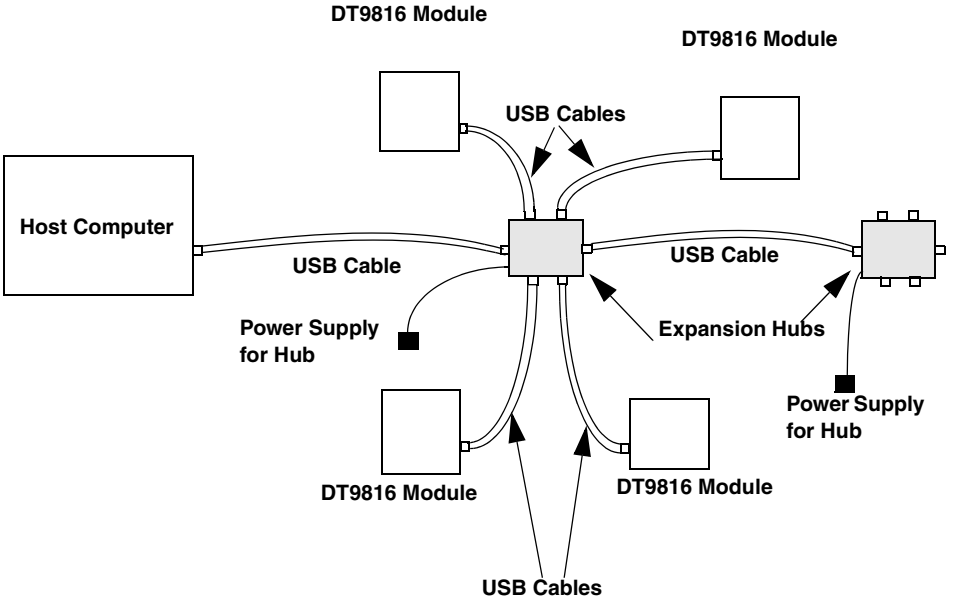

Figure 3: Attaching Multiple DT9816 Modules Using Expansion Hubs

Changing the Name of a Module (Optional)

To change the name of a DT9816 module, configure the device driver as follows:

1. From the Windows Start menu, select **Settings | Control Panel**.
2. From the Control Panel, double-click **Open Layers Control Panel**.
   The Data Acquisition Control Panel dialog box appears.
3. If you want to rename the module, click the DT9816 module that you want to rename, and then click **Edit Name.**
4. Enter a new name for the module, and then click **OK**. The name is used to identify the module in all subsequent applications.
5. When you are finished configuring the module, click **Close**.
6. Repeat steps 3 to 5 for the other modules that you want to configure.
7. Close the Data Acquisition Control Panel dialog box.

Continue with the instructions on wiring in Chapter 4 starting on page 33.

Wiring Signals to the Module

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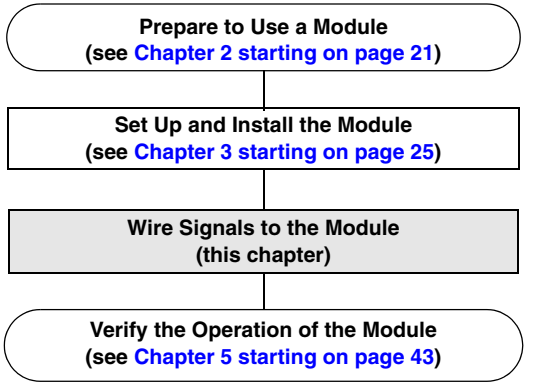
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(see Chapter 5 starting on page 43)

Preparing to Wire Signals

CAUTION:

To avoid electrostatic sensitivity, unplug your DT9816 module from the computer before wiring signals.

This section provides recommendations and information about wiring signals to a DT9816 module.

Wiring Recommendations

Keep the following recommendations in mind when wiring signals to a DT9816 module:

- Use individually shielded twisted-pair wire (size 16 to 26 AWG) in highly noisy electrical environments.
- Separate power and signal lines by using physically different wiring paths or conduits.
- To avoid noise, do not locate the box and cabling next to sources that produce high electromagnetic fields, such as large electric motors, power lines, solenoids, and electric arcs, unless the signals are enclosed in a mumetal shield.
- Prevent electrostatic discharge to the I/O while the box is operational.
- Connect all unused analog input channels to analog ground.

Wiring Locations

You wire signals to the DT9816 module using the screw terminals on the module. Table 2 lists the screw terminal assignments.

Table 2: DT9816 Screw Terminal Assignments

Terminal	Signal	Terminal	Signal
20	USB +5 V Out	40	Ext Trigger
19	Ground	39	Ext Clock
18	Counter 0 In	38	Ground
17	Counter 0 Out	37	Digital Output 7
16	Counter 0 Gate	36	Digital Output 6
15	Ground	35	Digital Output 5
14	Reserved	34	Digital Output 4
13	Reserved	33	Digital Output 3
12	Reserved	32	Digital Output 2
11	Reserved	31	Digital Output 1
10	2.5 V Reference	30	Digital Output 0
9	Analog Ground	29	Ground
8	Reserved	28	Digital Input 7
7	Reserved	27	Digital Input 6
6	Analog Input CH5	26	Digital Input 5
5	Analog Input CH4	25	Digital Input 4
4	Analog Input CH3	24	Digital Input 3
3	Analog Input CH2	23	Digital Input 2
2	Analog Input CH1	22	Digital Input 1
1	Analog Input CH0	21	Digital Input 0

Connecting Single-Ended Analog Input Signals

The DT9816 supports 6 single-ended analog input channels. Figure 4 shows how to connect single-ended voltage input signals (channels 0 and 1, in this case) to the screw terminals of a DT9816 module.

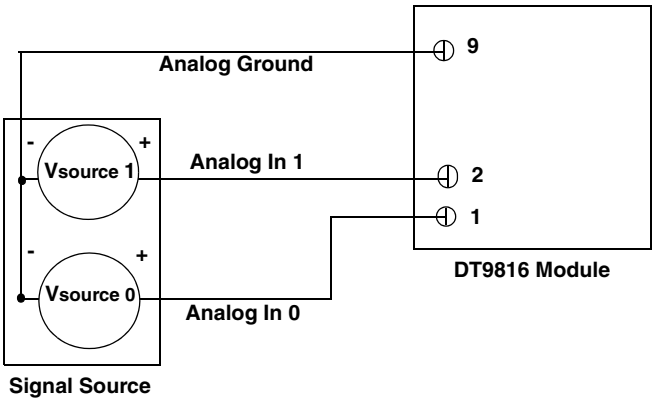

Figure 4: Connecting Single-Ended Inputs

Connecting Digital I/O Signals

Figure 5 shows how to connect digital input signals (lines 0 and 1, in this case) to the screw terminals of a DT9816 module.

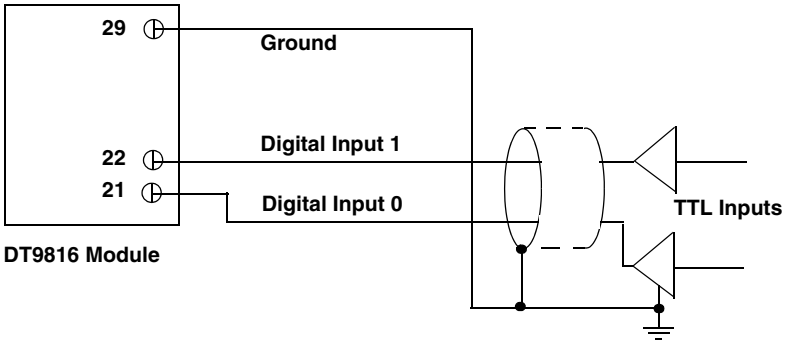

Figure 5: Connecting Digital Inputs

Figure 6 shows how to connect digital output signals (line 0, in this case) to the screw terminals of a DT9816 module.

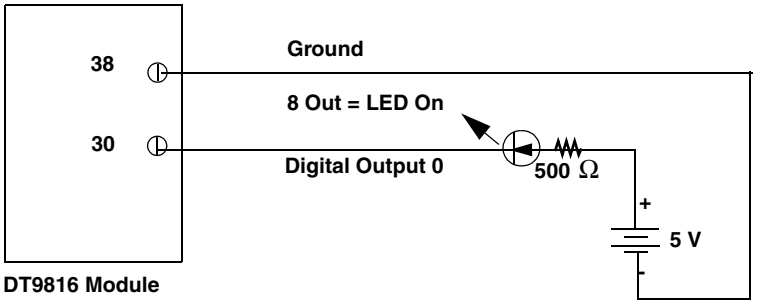

Figure 6: Connecting Digital Outputs

Connecting Counter/Timer Signals

The DT9816 module provides one counter/timer that you can use for the following operations:

- Event counting
- Frequency measurement
- Continuous pulse output (rate generation)

This section describes how to connect counter/timer signals for these operation modes. Refer to Chapter 6 for more information about using the counter/timers.

Connecting Signals for Event Counting

Figure 7 shows how to connect counter/timer signals to the screw terminals on the DT9816 module to perform an event counting operation using an external gate.

In this example, the counter counts the number of rising edges that occur on the Counter 0 In signal when the Counter 0 Gate signal is in the active state (as specified by software). Refer to Chapter 6 for more information.

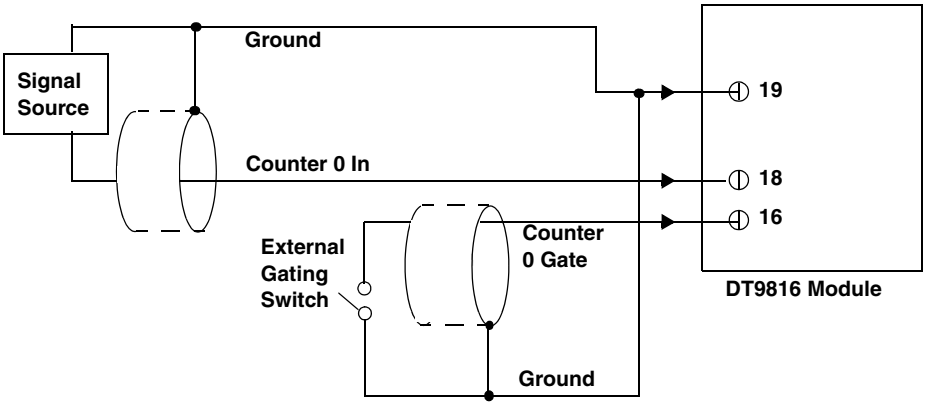

Figure 7: Connecting Counter/Timer Signals for an Event Counting Operation Using an External Gate

Figure 8 shows how to connect counter/timer signals to the screw terminals on the DT9816 module to perform an event counting operation without using a gate (also called a software gate). The counter counts the number of rising edges that occur on the Counter 0 In signal.

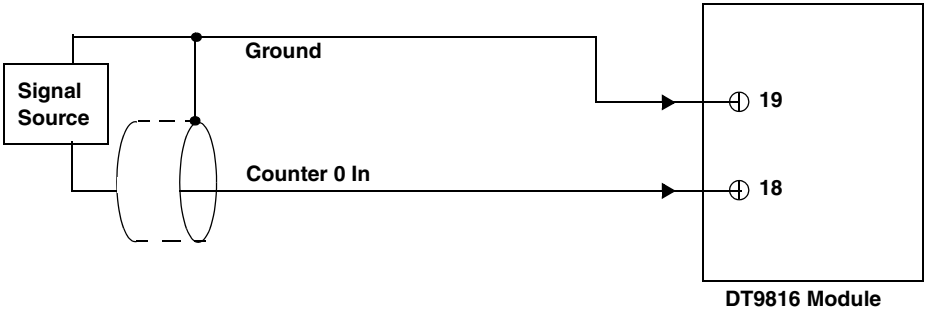

Figure 8: Connecting Counter/Timer Signals for an Event Counting Operation Without Using a Gate

Connecting Signals for Frequency Measurement

One way to measure frequency is to use the same wiring as a standard event counting application that does not use a gate (see Figure 8), and then use software (if using the SDK, call the **olDaMeasureFrequency** function) to determine the duration over which to count the number of pulses connected to the Counter 0 In signal. The frequency of the Counter 0 In signal is the number of counts divided by the duration of the **olDaMeasureFrequency** function.

If you need more accuracy than the **olDaMeasureFrequency** function provides, you can connect a pulse of a known duration to the Counter 0 Gate signal, as shown in Figure 9. In this case, the frequency of the Counter 0 In signal is the number of counts divided by the period of the signal connected to the Counter 0 Gate input.

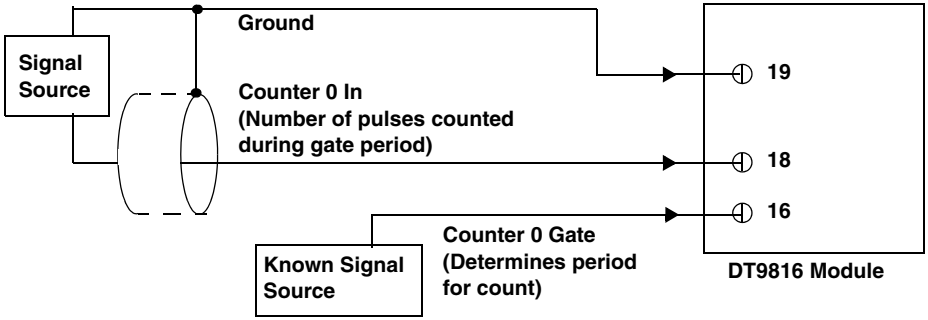

Figure 9: Connecting Counter/Timer Signals for a Frequency Measurement Operation Using an External Pulse

Connecting Signals for Rate Generation

Figure 10 shows how to connect counter/timer signals to the screw terminals of a DT9816 module to perform a rate generation (continuous pulse output) operation.

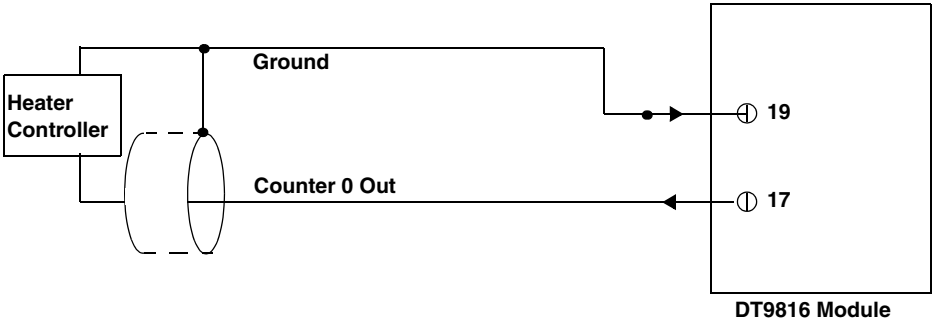

Figure 10: Connecting Counter/Timer Signals for a Rate Generation Operation

Verifying the Operation of a Module

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Using the Oscilloscope Function 47
Using the Chart Recorder Function 48
Using the Voltmeter Function 49
Using the File Viewer Tab 50
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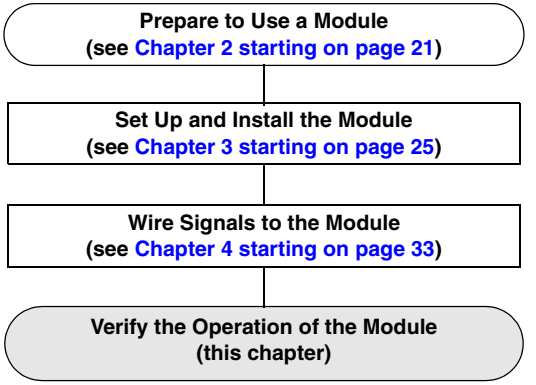
Using the Counter Function 53
Using the Rate Generator Function 54


Prepare to Use a Module
(see Chapter 2 starting on page 21)
Set Up and Install the Module
(see Chapter 3 starting on page 25)
Wire Signals to the Module
(see Chapter 4 starting on page 33)
Verify the Operation of the Module
(this chapter)

Overview

The GO! application allows you to measure and control signals from your DT9816 module right out of the box. Simply install the ECONseries software, connect your module to the PC, connect your signals to the module, and run the GO! application from the **Data Translation, Inc | ECONseries** program group.

The GO! application provides the following instrument-like functions for data acquisition, control, and display (the software shows only those functions that are supported by your module):

- **Oscilloscope**
  - Stream, plot, and analyze data from up to six analog input channels
  - Zoom in or out of live signals
  - Select the trigger type, level, and channel
  - Print your data or save it to an Excel file
- **Chart Recorder**
  - Record up to 31,990 data points from up to six analog input channels
  - Log data to an Excel file
- **Voltmeter**
  - Measure data from up to six analog input channels and view it in a 5-digit digital display
  - Display the maximum or true root mean square (RMS) value
- **File Viewer**
  - Load a previously saved Excel file
  - Scroll, zoom, or print your data
- **Digital Input** –Monitor the status of the digital inputs using LEDs

- **Digital Output** –Control the state of the digital outputs using switches
- **Counter** –Count pulses from the counter/timer for 1, 2, or 5 seconds or for an unlimited time
- **Rate Generator** –Control the frequency of a continuous pulse output signal from the counter/timer

The GO! application automatically detects and configures the first installed ECONseries module. If you have multiple ECONseries modules installed, you can select the module to use.

Notes: If no module is connected, a message box is displayed. If you want to continue with the GO! application, plug a DT9816 module into any USB port of your PC, and then click **Rescan**. Otherwise, click **Quit** to exit from the GO! application.

If you have multiple DT9816 modules, you can run multiple instances of the GO! application, if you wish. Each instance of the application detects the available (not already in use) modules for your convenience.

Press F1 at any time to get help on any of the functions of the GO! application.

Using the Oscilloscope Function

The verify the analog input operation of your DT9816 module using the Oscilloscope function of the GO! application, do the following:

1. Connect a known voltage source, such as the output of a function generator, to analog input channel 0 on the DT9816 module (single-ended mode). Refer to page 37 for an example of how to connect a single-ended analog input.
2. Under Visible Channels on the Oscilloscope tab, ensure that only channel 0 is selected.
   The analog input data from channel 0 is continuously displayed.
3. Zoom in on your data by using your left mouse button to create a zoom rectangle around the region that you are interested in.
4. When you are finished, snap back to the standard voltage range of the module by clicking the **Unzoom** button.

Using the Chart Recorder Function

To verify the analog input operation of your DT9816 module using the Chart Recorder function of the GO! application, do the following:

1. Connect a known voltage source, such as the output of a function generator, to analog input channel 0 on the DT9816 module (single-ended mode). Refer to page 37 for an example of how to connect a single-ended analog input.
2. Under Visible Channels on the Chart Recorder tab, ensure that only channel 0 is selected.
3. Click **Start Recording**, and enter **Test** for the filename.
   The analog input data from channel 0 is displayed on the screen and logged to the Test.xls file.
4. After a few seconds, click **Stop Recording**.
5. Launch Excel and open the file called Test.xls to review the data you just recorded.

Using the Voltmeter Function

To verify the analog input operation of your DT9816 module using the Voltmeter function of the GO! application, do the following:

1. Connect a known voltage source, such as the output of a function generator, to analog input channel 0 on the DT9816 module (single-ended mode). Refer to page 37 for an example of how to connect a single-ended analog input.
2. Under Visible Channels on the Voltmeter tab, ensure that only channel 0 is selected.
3. Click **Normal** under Display Settings.
   The analog input data from analog input channel 0 is converted into digital format and displayed.

Note that the 5-digit display is refreshed twice per second.

Using the File Viewer Tab

To verify the analog input operation of your DT9816 module using the File Viewer function of the GO! application, do the following:

1. Connect a known voltage source, such as the output of a function generator, to analog input channel 0 on the DT9816 module (single-ended mode). Refer to page 37 for an example of how to connect a single-ended analog input.
2. Under Visible Channels on the Chart Recorder tab, ensure that only channel 0 is selected.
3. Click **Start Recording**, and enter **Test** for the filename.
   The analog input data from channel 0 is displayed on the screen and logged to the Test.xls file.
4. After a few seconds, click **Stop Recording**.
5. Click on the **File Viewer** tab, and click **Open File**.
6. Click on the filename **Test.xls**.
7. Click **Open**.
8. Scroll through the data in the file using the slider at the bottom of the File Viewer screen.

Using the Digital Input Function

To verify the digital input operation of your DT9816 module using the Digital Input function of the GO! application, do the following:

1. Connect a digital input signal to a digital input line on the module. Refer to page 38 for an example of how to connect a digital input.
2. Read the status of the LEDs.
   If digital input line 0 is high, the LED for line 0 turns green (on). If digital input line 0 is low, the LED for line 0 turns gray (off).

The DT9816 module supports 8 digital input lines; the GO! application supports all 8 lines.

Using the Digital Output Function

To verify the digital output operation of your DT9816 module using the Digital Output function of the GO! application, do the following:

1. Connect a device to a digital output line on the module. Refer to page 38 for an example of how to connect a digital output.
2. Click the switches to change the state of your device.
3. Check that the device has been changed as expected.
   For example, if you connect a simple set of LEDs, the LED corresponding to a line you switch on with the Digital Output function should turn green (on).

The DT9816 module supports 8 digital output lines; the GO! application supports all 8 lines.

Using the Counter Function

To verify the event counting operation of your module using the Counter function of the GO! application, do the following:

1. Wire an external clock source to the Counter 0 In signal on your DT9816 module. (Refer to page 41 for an example of how to connect an external clock to the counter/timer channel.)
2. Click **2 Seconds**, and click **Start Counting**.
   The number of counts is displayed on the screen.
   When 2 seconds have elapsed, the operation stops automatically.

Using the Rate Generator Function

To verify the rate generation operation of your module using the Rate Generator function of the GO! application, do the following:

1. Connect a scope or similar device that accepts a pulse output signal to the Counter 0 Out signal of your DT9816 module. (Refer to page 42 for an example of how to connect signals for rate generation.)
2. Use the slider to change the frequency of the continuous pulse output signal.
   If you are using a scope, you can see the frequency of the pulse output signal change as you move the slider.

Part 2:
Using Your Module

Principles of Operation

Analog Input Features 59
Digital I/O Features 65
Counter/Timer Features 67

Figure 11 shows a block diagram of the DT9816 module.

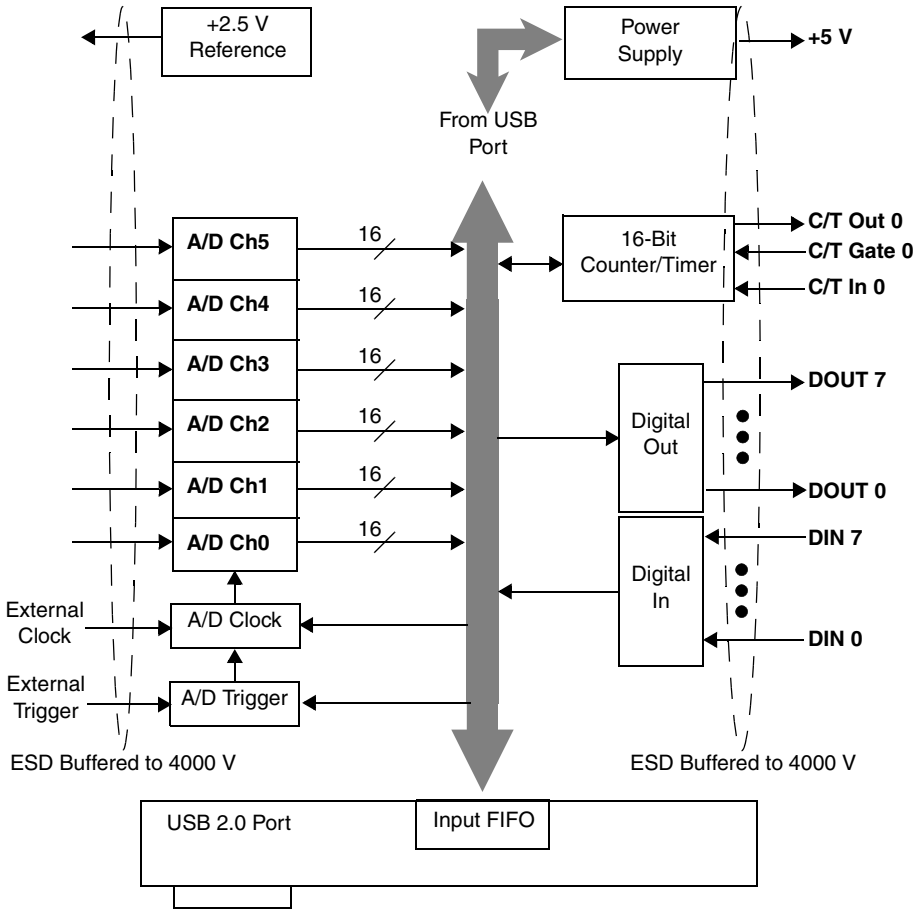


Figure 11: Block Diagram of the DT9816 Module

Analog Input Features

This section describes the following features of analog input (A/D) operations on the DT9816 module:

- Input resolution, described below
- Analog input channels, described below
- Input ranges and gains, described on page 60
- Input sample clock sources, described on page 61
- Analog input conversion modes, described on page 61
- Input triggers, described on page 63
- Data format and transfer, described on page 63
- Error conditions, described on page 64

Input Resolution

The resolution of the A/D subsystem on the DT9816 module is 16-bits. This resolution is fixed; it cannot be programmed in software.

Analog Input Channels

The DT9816 provides six single-ended simultaneous analog input channels. You can acquire data from a single analog input channel or from a group of analog input channels on the module.

Note: To maintain simultaneous operation, all analog input connections must have the same lead lengths.

The following subsections describe how to specify the channels.

Specifying a Single Analog Input Channel

The simplest way to acquire data from a single analog input channel is to specify the channel for a single-value analog input operation using software; refer to page 61 for more information about single-value operations.

You can also specify a single channel using the analog input channel-gain list, described in the next section.

Specifying One or More Analog Input Channels

You can read data from one or more analog input channels using an analog input channel-gain list. Group the channels in the list sequentially (starting either with 0 or with any other analog input channel) in ascending order. You cannot specify the same channel more than once in the list.

Using software, specify the channels you want to sample. You can enter up to 6 entries in the channel-gain list for this module. Refer to page 61 for more information about the supported conversion modes.

Input Ranges and Gains

The DT9816 provides an input range of -10 to +10 V or -5 to +5 V. Use software to specify the range as -10 to +10 V with a gain of 1, or -5 to +5 V with a gain of 2.

Note: This is the range for the entire analog input subsystem, not the range per channel.

Input Sample Clock Sources

You can pace an analog input operation on a DT9816 module using a software clock source. Using software, specify the clock source as internal, then specify the clock frequency at which to pace the operation. The DT9816-A supports an A/D clock frequency of 60 Hz to 150 MHz; the DT9816 supports an A/D clock frequency of 60 Hz to 50 MHz.

According to sampling theory (Nyquist Theorem), specify a frequency that is at least twice as fast as the input's highest frequency component. For example, to accurately sample a 2 kHz signal, specify a sampling frequency of at least 4 kHz. Doing so avoids an error condition called *aliasing*, in which high frequency input components erroneously appear as lower frequencies after sampling.

Analog Input Conversion Modes

The DT9816 supports the following conversion modes:

- Single-value operations
- Continuous scan operations

The following subsections describes the conversion modes in more detail.

Single-Value Operations

Single-value operations are the simplest to use. Using software, you specify the range, gain, and analog input channel. The module acquires the data from the specified channel and returns the data immediately. For a single-value operation, you cannot specify a clock source, trigger source, scan mode, or buffer.

Single-value operations stop automatically when finished; you cannot stop a single-value operation.

Continuous Scan Mode

Use continuous scan mode if you want to accurately control the period between successive simultaneous conversions of all channels in a channel-gain list.

When it receives a software trigger, the module cycles through the channel-gain list, acquiring and converting the data for each entry in the list (this process is defined as the scan). The module then wraps to the start of the channel-gain list and repeats the process continuously until either the allocated buffers are filled or until you stop the operation. Refer to page 63 for more information about buffers.

The conversion rate is determined by the frequency of the internal sample clock; refer to page 61 for more information about the internal sample clock. The sample rate, which is the rate at which a single entry in the channel-gain list is sampled, is the same as the conversion rate due to the simultaneous nature of the module.

To select continuous scan mode, use software to specify the data flow as continuous.

Figure 12 illustrates continuous scan mode using a channel-gain list with three entries: channel 0, channel 1, and channel 2. In this example, analog input data is acquired simultaneously on all channels on each clock pulse of the input sample clock. Data is acquired continuously.

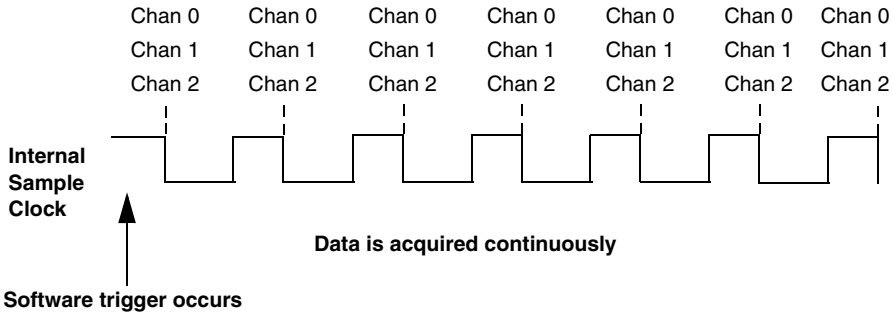


Figure 12: Continuous Scan Mode

Input Triggers

The DT9816 supports a software trigger or an external TTL trigger for starting an analog input operation. When the computer issues a write to the DT9816 module, data acquisition begins. Acquisition stops when the specified number of samples has been acquired (if the buffer wrap mode is none, described on page 64), or when you stop the operation. Note that when you stop the operation, the module completes the reading of the channel-gain list.

Using software, specify the trigger source as a software trigger or an external trigger. The external trigger is initiated by a high to low transition on the A/D external TTL trigger input.

Data Format and Transfer

DT9816 modules use binary data encoding, where 0000 represents negative full-scale, and FFFFh represents positive full-scale. Use software to specify the data encoding as binary. The ADC outputs FFFFh for above-range signals, and 0000 for below-range signals.

Before you begin acquiring data, you must allocate buffers to hold the data. A Buffer Done message is returned whenever a buffer is filled. This allows you to move and/or process the data as needed.

We recommend that you allocate a minimum of three buffers for analog input operations, specifying one of the following buffer wrap modes in software:

- **None** –Data is written to multiple allocated input buffers continuously; when no more empty buffers are available, the operation stops. If wrap mode is none, the module guarantees gap-free data.
- **Multiple** –Data is written to multiple allocated input buffers continuously; if no more empty buffers are available, the module overwrites the data in the current buffer, starting with the first location in the buffer. This process continues indefinitely until you stop it. If wrap mode is multiple, the module does not guarantee gap-free data.

Error Conditions

An overrun condition is reported if the A/D sample clock rate is too fast. This error is reported if a new A/D sample clock pulse occurs while the ADC is busy performing a conversion from the previous A/D sample clock pulse. The host computer can clear this error. To avoid this error, use a slower sampling rate or increase the buffer size and/or number of buffers.

Digital I/O Features

This section describes the following features of digital I/O operations on the DT9816:

- Digital I/O lines
- Resolution
- Operation modes

Digital I/O Lines

The DT9816 module includes 8 digital input and 8 digital output lines.

Using DT-Open Layers, you can specify the digital I/O line that you want to read or write in a single-value digital I/O operation. Refer to page 66 for more information about single-value operations.

A digital line is high if its value is 1; a digital line is low if its value is 0. On power up or reset, a low value (0) is output from each of the digital output lines.

Note: You can also read or write to the digital I/O lines using functions that access the hardware registers on the module directly. Refer to Appendix C starting on page 121 for more information on these functions.

Resolution

The DT9816 provides 16 digital lines that are dedicated, 8 each, to the DIN and DOUT subsystems. By default, these lines are organized as two 8-bit ports. Because these are dedicated lines, you cannot combine the digital ports into one port to change resolution.

Operation Modes

The DT9816 supports single-value digital I/O operations only. For a single-value operation, use software to specify the digital I/O port (the gain is ignored). The DT9816 then reads data from or writes data to the digital lines associated with that port (determined by the resolution setting).

Single-value operations stop automatically when finished; you cannot stop a single-value operation.

Counter/Timer Features

This section describes the following features of counter/timer (C/T) operations on the DT9816 module:

- C/T channel, described below
- C/T clock sources, described on page 68
- Gate types, described on page 68
- Pulse types and duty cycles, described on page 69
- C/T operation modes, described on page 69

C/T Channel

The DT9816 module provides one 16-bit counter/timer. The counter accepts a clock input signal and gate input signal and outputs a pulse (pulse output signal), as shown in Figure 13.

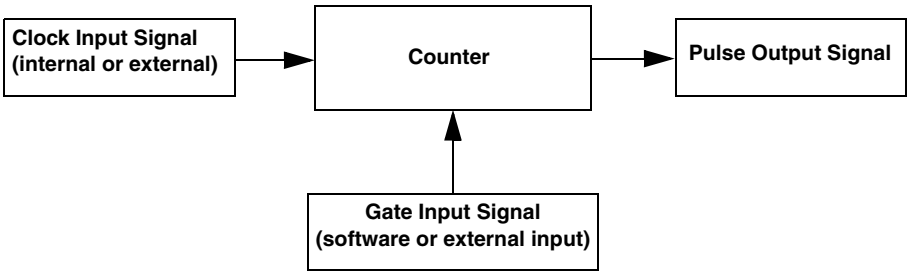


Figure 13: Counter/Timer Channel

C/T Clock Sources

The following clock sources are available for the counter/timer:

- **Internal clock** – Through software, specify the clock source as internal, and specify the frequency at which to pace the counter/timer operation. The frequency of the internal C/T clock can range from 60 Hz to 6 MHz.
- **External clock** – An external clock is useful when you want to pace counter/timer operations at rates not available with the internal clock or if you want to pace at uneven intervals.

  Connect an external clock with a maximum recommended frequency of 6 MHz to the Counter 0 In signal on the DT9816 module. Using software, specify the C/T clock source as external, and specify a clock divider between 2 and 65534 to determine the actual frequency at which to pace the counter/timer operation. For example, if you connect a 6 MHz external C/T clock and use a clock divider of 2, the resulting C/T output frequency is 3 MHz. Counter/timer operations start on the falling edge of the Counter 0 In signal.

Gate Types

The edge or level of the Counter 0 Gate signal determines when a counter/timer operation is enabled. Using software, you can specify one of the following gate types:

- **None** –A software command enables any counter/timer operation immediately after execution.
- **Logic-high level external gate input** –Enables a counter/timer operation when Counter 0 Gate is high, and disables a counter/timer operation when Counter 0 Gate is low. Note that this gate type is used for event counting and rate generation modes; refer to page 69 for more information about these modes.

Pulse Duty Cycles

Counter/timer output signals from the DT9816 module are high-to-low going signals. The low portion of the total pulse output period is the active portion of the counter/timer clock output signal.

The duty cycle (or pulse width) indicates the percentage of the total pulse output period that is active. In rate generation mode, the duty cycle is fixed at 50% for the DT9816 module. Figure 14 illustrates a high-to-low going output pulse with a duty cycle of 50%.

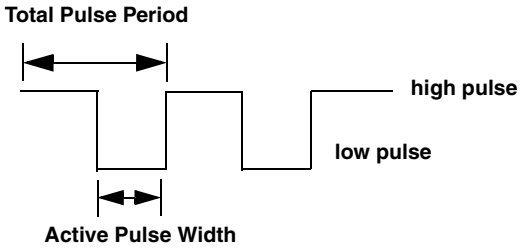


Figure 14: Example of a Pulse Output SIgnal with a 50% Duty Cycle (High-to-Low Going)

Counter/Timer Operation Modes

The DT9816 module supports the following counter/timer operation modes:

- Event counting
- Frequency measurement
- Rate generation

Event Counting

Use event counting mode if you want to count the number of falling edges that occur on Counter 0 In when the gate is active (high-level). Refer to page 68 for information about specifying the active gate type.

You can count a maximum of 65,536 events before the counter rolls over to 0 and starts counting again.

For event counting operations, use software to specify the counter/timer mode as count, the C/T clock source as external, and the active gate type as high-level.

Make sure that the signals are wired appropriately. Refer to Chapter 4 for an example of connecting an event counting application.

Frequency Measurement

Using software, specify the counter/timer mode as count, the clock source as external, and then call the olDaMeasureFrequency function.

Our function uses the Windows timer (which has a resolution of 1 ms) to specify the duration. If you need more accuracy than the Windows timer provides, you can connect a pulse of a known duration to the Counter 0 Gate signal.

If you are using a known pulse connected to the gate pin for the duration, specify the active gate in software (high level). When the operation starts, read the number of counts that occurred when the gate was active.

You can determine the frequency of the clock input signal using the following equation:

$$\text{Frequency Measurement} = \frac{\text{Number of Events}}{\text{Measurement Period}}$$

Make sure that the signals are wired appropriately. Refer to Chapter 4 for an example of connecting a frequency measurement application.

Rate Generation

Use rate generation mode to generate a continuous pulse output signal from Counter 0 Out; this mode is sometimes referred to as continuous pulse output or pulse train output.

The pulse output operation is enabled whenever the Counter 0 Gate signal is active (high level or software gate). While the pulse output operation is enabled, the counter outputs a high-to-low going pulse with a pulse width of 50% continuously. As soon as the operation is disabled, rate generation stops.

The frequency of the output is determined by the C/T clock source (either internal or external) and, for an external clock source, the clock divider used. You can generate an output signal from Counter 0 Out with a frequency of 60 Hz to 6 MHz.

To specify rate generation mode, use software to specify the counter/timer mode as rate, the C/T clock source as either internal or external, the clock divider (2 to 65534) if external, and the active gate type (low-level, high-level, or software gate). Refer to page 68 for more information about gate types.

Make sure that the signals are wired appropriately. Refer to Chapter 4 for an example of connecting a rate generation application.

Supported Device Driver Capabilities

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The DT9816 Device Driver provides support for the analog input (A/D), digital input (DIN), digital output (DOUT), and counter/timer (C/T) subsystems on the DT9816 module.

Table 3: DT9816 Series Subsystems

DT9816	A/D	D/A	DIN	DOUT	C/T
Total Subsystems on Module	1	0	1	1	1

The tables in this chapter summarize the features available for use with the DataAcq SDK and the DT9816 module. The DataAcq SDK provides functions that return support information for specified subsystem capabilities at run-time.

The first row in each table lists the subsystem types. The first column in each table lists all possible subsystem capabilities. A description of each capability is followed by the parameter used to describe that capability in the DataAcq SDK.

Note: Blank fields represent unsupported options.

The DataAcq SDK uses the functions **olDaGetSSCaps** (for those queries starting with OLSSC) and **olDaGetSSCapsEx** (for those queries starting with OLSSCE) to return the supported subsystem capabilities for a device.

For more information, refer to the description of these functions in the DataAcq SDK online help. See the *DataAcq User's Manual* for information on launching this help file.

Data Flow

Table 4: DT9816 Data Flow Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Single-Value Operation Support OLSSC_SUP_SINGLEVALUE	Yes		Yes	Yes	No
Continuous Operation Support OLSSC_SUP_CONTINUOUS	Yes				Yes
Continuous Operation until Trigger Event Support OLSSC_SUP_CONTINUOUS_PRETRIG					
Continuous Operation before & after Trigger Event OLSSC_SUP_CONTINUOUS_ABOUTTRIG					
DT-Connect Support OLSSC_SUP_DTCONNECT					
Continuous DT-Connect Support OLSSC_SUP_DTCONNECT_CONTINUOUS					
Burst DT-Connect Support OLSSC_SUP_DTCONNECT_BURST					

Buffering

Table 5: DT9816 Buffering Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Buffer Support OLSSC_SUP_BUFFERING	Yes				
Single Buffer Wrap Mode Support OLSSC_SUP_WRPSINGLE	Yes				
Multiple Buffer Wrap Mode Support OLSSC_SUP_WRPMULTIPLE	Yes				
Inprocess Buffer Flush Support OLSSC_SUP_INPROCESSFLUSH	Yes				
Waveform Generation Mode Support OLSSC_SUP_WAVEFORM_MODE					

DMA

Table 6: DT9816 DMA Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Number of DMA Channels OLSSC_NUMDMACHANS	0		0	0	0
Supports Gap Free Data with No DMA OLSSC_SUP_GAPFREE_NODMA	Yes				
Supports Gap Free Data with Single DMA OLSSC_SUP_GAPFREE_SINGLEDMA					
Supports Gap Free Data with Dual DMA OLSSC_SUP_GAPFREE_DUALDMA					

Triggered Scan Mode

Table 7: DT9816 Triggered Scan Mode Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Triggered Scan Support OLSSC_SUP_TRIGSCAN					
Maximum Number of CGL Scans per Trigger OLSSC_MAXMULTISCAN	0		0	0	0
Supports Scan per Trigger Event Triggered Scan OLSSC_SUP_RETRIGGER_SCAN_PER_ TRIGGER					
Supports Internal Retriggered Triggered Scan OLSSC_SUP_RETRIGGER_INTERNAL					
Extra Retrigger Support OLSSC_SUP_RETRIGGER_EXTRA					
Maximum Retrigger Frequency OLSSCE_MAXRETRIGGER	0		0	0	0
Minimum Retrigger Frequency OLSSCE_MINRETRIGGER	0		0	0	0

Gain

Table 8: DT9816 Gain Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Maximum Channel-Gain List Depth OLSSC_CGLDEPTH	6[a]		0	0	0
Sequential Channel-Gain List Support OLSSC_SUP_SEQUENTIAL_CGL	Yes				
Zero Start Sequential Channel-Gain List Support OLSSC_SUP_ZEROSEQUENTIAL_CGL	Yes				
Random Channel-Gain List Support OLSSC_SUP_RANDOM_CGL	Yes[b]				
Simultaneous Sample-and-Hold Support OLSSC_SUP_SIMULTANEOUS_SH	Yes				
Channel List Inhibit Support OLSSC_SUP_CHANNELLIST_INHIBIT					
Programmable Gain Support OLSSC_SUP_PROGRAMGAIN	Yes				
Number of Gains OLSSC_NUMGAINS	2		1	1	0
Noncontiguous Channels in Channel-Gain List OLSSC_NONCONTIGUOUS_CHANNELNUM	16		0	0	0
AutoRanging Support OLSSC_SUP_SINGLEVALUE_AUTORANGE					

a. You cannot specify the same channel more than once in the list.

b. Place channels in your CGL in ascending order. All channels are sampled simultaneously with data returned in ascending channel order; if your CGL does not match, you will have unexpected results.

Synchronous Digital I/O

Table 9: DT9816 Synchronous Digital I/O Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Synchronous Digital I/O Support OLSSC_SUP_SYNCHRONOUS_DIGITALIO					
Maximum Synchronous Digital I/O Value OLSSC_MAX_DIGITALIOLIST_VALUE	1		0	0	0

Channels

Table 10: DT9816 Channel Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Number of Channels OLSSC_NUMCHANNELS	6[a]		1	1	1
SE Support OLSSC_SUP_SINGLEENDED	Yes				
SE Channels OLSSC_MAXSECHANS	6		0	0	0
DI Support OLSSC_SUP_DIFFERENTIAL			Yes	Yes	Yes
DI Channels OLSSC_MAXDICHANS	0		1	1	1
DT2896 Channel Expansion Support OLSSC_SUP_EXP2896					
DT727 Channel Expansion OLSSC_SUP_EXP727					

a. The DT9816 provides analog input channels 0 to 5.

Filters

Table 11: DT9816 Filter Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Filter/Channel Support OLSSC_SUP_FILTERPERCHAN					
Number of Filters OLSSC_NUMFILTERS	1		1	1	0

Ranges

Table 12: DT9816 Range Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Number of Voltage Ranges OLSSC_NUMRANGES	1[a]		0	0	0
Range per Channel Support OLSSC_SUP_RANGEPERCHANNEL	Yes				

a. The input range for the module is -10 to +10 V.

Resolution

Table 13: DT9816 Resolution Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Software Programmable Resolution OLSSC_SUP_SWRESOLUTION			Yes	Yes	
Number of Resolutions OLSSC_NUMRESOLUTIONS	1[a]		1[b]	1[b]	1[c]

a. The DT9816 provides 16-bit resolution.
b. The DIN and DOUT subsystems are configured as two separate 8-bit ports.
c. The resolution of the counter/timer subsystem is 16.

Triggers

Table 14: DT9816 Trigger Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Software Trigger Support OLSSC_SUP_SOFTTRIG	Yes				Yes
External Trigger Support OLSSC_SUP_EXTERNTRIG	No[a]				Yes
Positive Threshold Trigger Support OLSSC_SUP_THRESHTRIGPOS					
Negative Threshold Trigger Support OLSSC_SUP_THRESHTRIGNEG					
Analog Event Trigger Support OLSSC_SUP_ANALOGEVENTTRIG					
Digital Event Trigger Support OLSSC_SUP_DIGITALEVENTTRIG					
Timer Event Trigger Support OLSSC_SUP_TIMEREVENTTRIG					
Number of Extra Triggers OLSSC_NUMEXTRATRIGGERS	1[a]		0	0	0

a. Falling-edge external triggers are supported through the OLSCC_NUMEXTRATRIGGERS capability.

Clocks

Table 15: DT9816 Clock Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Internal Clock Support OLSSC_SUP_INTCLOCK	Yes				Yes
External Clock Support OLSSC_SUP_EXTCLOCK	Yes				Yes
Simultaneous Input/Output on a Single Clock Signal OLSSC_SIMULTANEOUS_CLOCKING	Yes				
Number of Extra Clocks OLSSC_NUMEXTRACLOCKS	0		0	0	0
Base Clock Frequency OLSSCE_BASECLOCK	48 MHz		0	0	12 MHz
Maximum External Clock Divider OLSSCE_MAXCLOCKDIVIDER	2		1	1	65534[a]
Minimum External Clock Divider OLSSCE_MINCLOCKDIVIDER	1		1	1	2
Maximum Throughput OLSSCE_MAXTHROUGHPUT	150 kHz		0	0	6 MHz
Minimum Throughput OLSSCE_MINTHROUGHPUT	60 Hz		0	0	60 Hz

a. The module only supports even number values for the clock divider. Odd values are rounded down.

Counter/Timers

Table 16: DT9816 Counter/Timer Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Cascading Support OLSSC_SUP_CASCADING					
Event Count Mode Support OLSSC_SUP_CTMODE_COUNT					Yes
Generate Rate Mode Support OLSSC_SUP_CTMODE_RATE					Yes
One-Shot Mode Support OLSSC_SUP_CTMODE_ONESHOT					
Repetitive One-Shot Mode Support OLSSC_SUP_CTMODE_ONESHOT_RPT					
Up/Down Counting Mode Support OLSSC_SUP_CTMODE_UP_DOWN					
Edge-to-Edge Measurement Mode Support OLSSC_SUP_CTMODE_MEASURE					
Continuous Edge-to-Edge Measurement Mode Support OLSSC_SUP_CTMODE_CONT_MEASURE					
High to Low Output Pulse Support OLSSC_SUP_PLS_HIGH2LOW					Yes
Low to High Output Pulse Support OLSSC_SUP_PLS_LOW2HIGH					
None (internal) Gate Type Support OLSSC_SUP_GATE_NONE					Yes
High Level Gate Type Support OLSSC_SUP_GATE_HIGH_LEVEL					Yes
Low Level Gate Type Support OLSSC_SUP_GATE_LOW_LEVEL					
High Edge Gate Type Support OLSSC_SUP_GATE_HIGH_EDGE					

Table 16: DT9816 Counter/Timer Options (cont.)

DT9816	A/D	D/A	DIN	DOUT	C/T
Low Edge Gate Type Support OLSSC_SUP_GATE_LOW_EDGE					
Level Change Gate Type Support OLSSC_SUP_GATE_LEVEL					
High Level Gate Type with Input Debounce OLSSC_SUP_GATE_HIGH_LEVEL_DEBOUNCE					
Low Level Gate Type with Input Debounce Support OLSSC_SUP_GATE_LOW_LEVEL_DEBOUNCE					
High Edge Gate Type with Input Debounce OLSSC_SUP_GATE_HIGH_EDGE_DEBOUNCE					
Low Edge Gate Type with Input Debounce Support OLSSC_SUP_GATE_LOW_EDGE_DEBOUNCE					
Level Change Gate Type with Input Debounce OLSSC_SUP_GATE_LEVEL_DEBOUNCE					
Fixed Pulse Width Support OLSSC_SUP_FIXED_PULSE_WIDTH					Yes[a]
Quadrature Decoder OLSSC_SUP_QUADRATURE_DECODER					

a. The pulse width (duty cycle) if fixed at 50% when rate generation mode is used.

Miscellaneous

Table 17: DT9816 Miscellaneous Options

DT9816	A/D	D/A	DIN	DOUT	C/T
Simultaneous Start List Support OLSSC_SUP_SIMULTANEOUS_START					
Pause Operation Support OLSSC_SUP_PAUSE					
Asynchronous Operation Support OLSSC_SUP_POSTMESSAGE	Yes				
Binary Encoding Support OLSSC_SUP_BINARY	Yes		Yes	Yes	Yes
Twos Complement Support OLSSC_SUP_2SCOMP					
Interrupt Support OLSSC_SUP_INTERRUPT					Yes
FIFO in Data Path Support OLSSC_SUP_FIFO	Yes				
Output FIFO Size OLSSC_FIFO_SIZE_IN_K					
Data Processing Capability OLSSC_SUP_PROCESSOR	Yes				Yes
Software Calibration Support OLSSC_SUP_SWCAL					

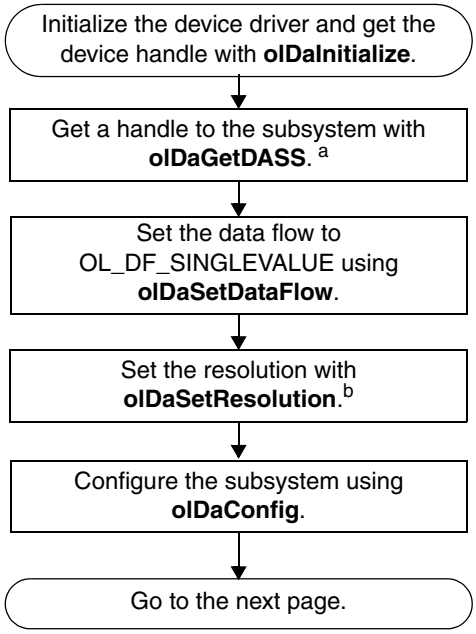
Programming Flowcharts

Single-Value Operations 89
Continuous A/D Operations 91
Event Counting Operations 93
Frequency Measurement Operations 95
Pulse Output Operations. 97

The following flowcharts show the steps required to perform analog input, digital I/O, and counter/timer operations on the DT9816 module using DT-Open Layers. For illustration purposes, the DataAcq SDK functions are shown; however, the concepts apply to all DT-Open Layers-compatible software.

Note that many steps represent several substeps; if you are unfamiliar with the detailed operations involved with any one step, refer to the indicated page for detailed information. Optional steps appear in shaded boxes.

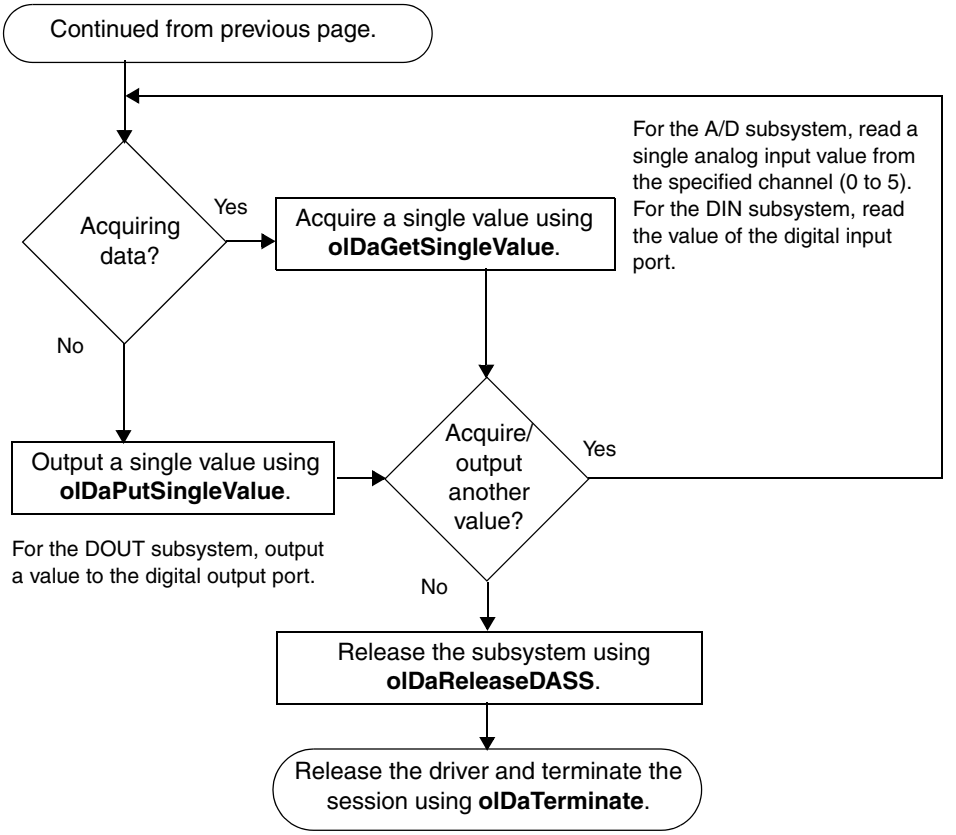
Single-Value Operations


Initialize the device driver and get the device handle with **olDaInitialize**.
Get a handle to the subsystem with **olDaGetDASS**. a
Set the data flow to OL_DF_SINGLEVALUE using **olDaSetDataFlow**.
Set the resolution with **olDaSetResolution**.b
Configure the subsystem using **olDaConfig**.
Go to the next page.

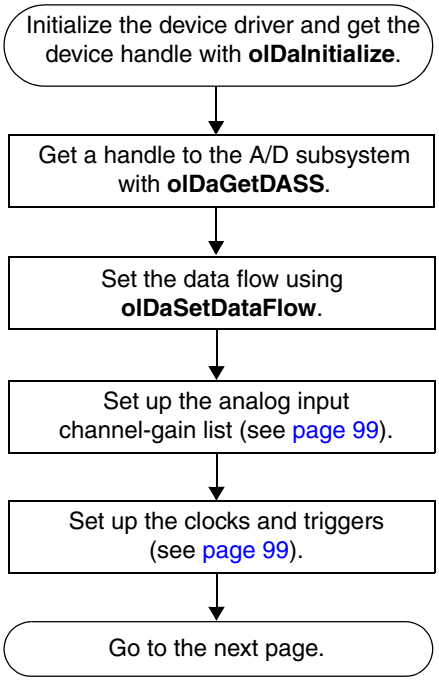
a Specify A/D subsystem 0 for an analog input operation, DIN subsystem 0 for a digital input operation, or DOUT subsystem 1 for a digital output operation.

b. The DIN and the DOUT subsystems use separate digital I/O lines. The resolution of the DIN and DOUT subsystems is fixed at 8-bits.

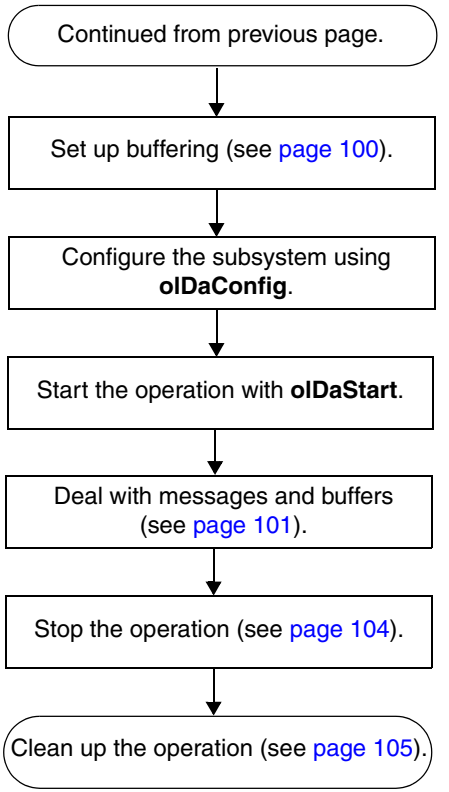
Single-Value Operations (cont.)


Continued from previous page.
Acquiring data?
Yes
No
Acquire a single value using **olDaGetSingleValue**.
For the A/D subsystem, read a single analog input value from the specified channel (0 to 5). For the DIN subsystem, read the value of the digital input port.
Output a single value using **olDaPutSingleValue**.
For the DOUT subsystem, output a value to the digital output port.
Acquire/ output another value?
Yes
No
Release the subsystem using **olDaReleaseDASS**.
Release the driver and terminate the session using **olDaTerminate**.

Continuous A/D Operations

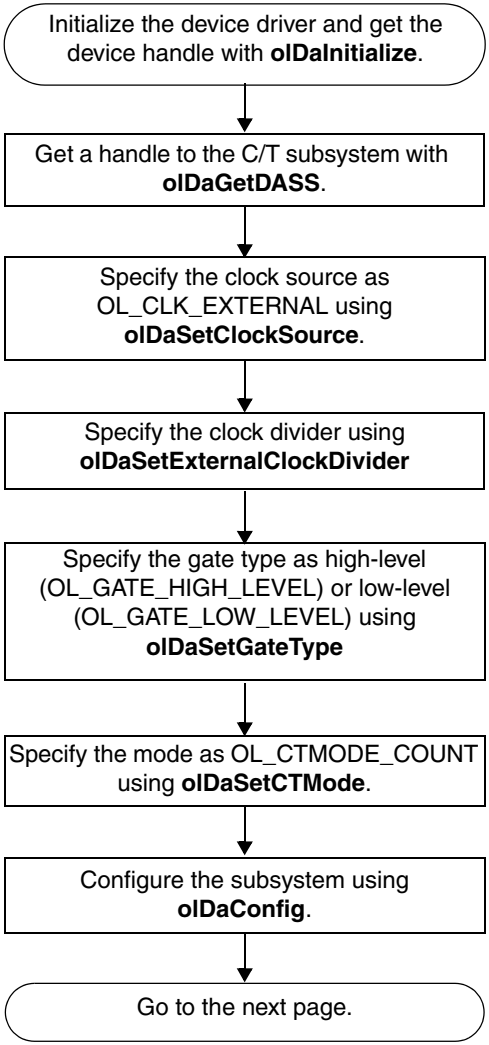

Initialize the device driver and get the device handle with **olDaInitialize**.
Get a handle to the A/D subsystem with **olDaGetDASS**.
Set the data flow using **olDaSetDataFlow**.
Specify OL_DF_CONTINUOUS (the default value).
Set up the analog input channel-gain list (see page 99).
Set up the clocks and triggers (see page 99).
Go to the next page.

Continuous A/D Operations (cont.)

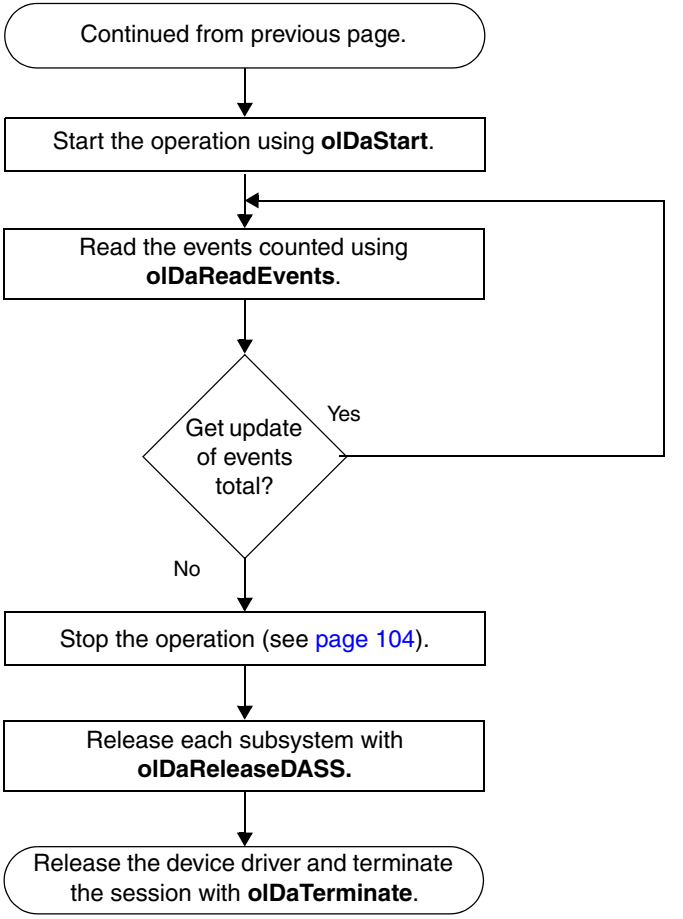

Continued from previous page.
Set up buffering (see page 100).
Configure the subsystem using **olDaConfig**.
Start the operation with **olDaStart**.
Deal with messages and buffers (see page 101).
Stop the operation (see page 104).
Clean up the operation (see page 105).

After you configure the subsystem, you can use **olDaGetClockFrequency** to return the actual frequency of the internal clock.

Event Counting Operations

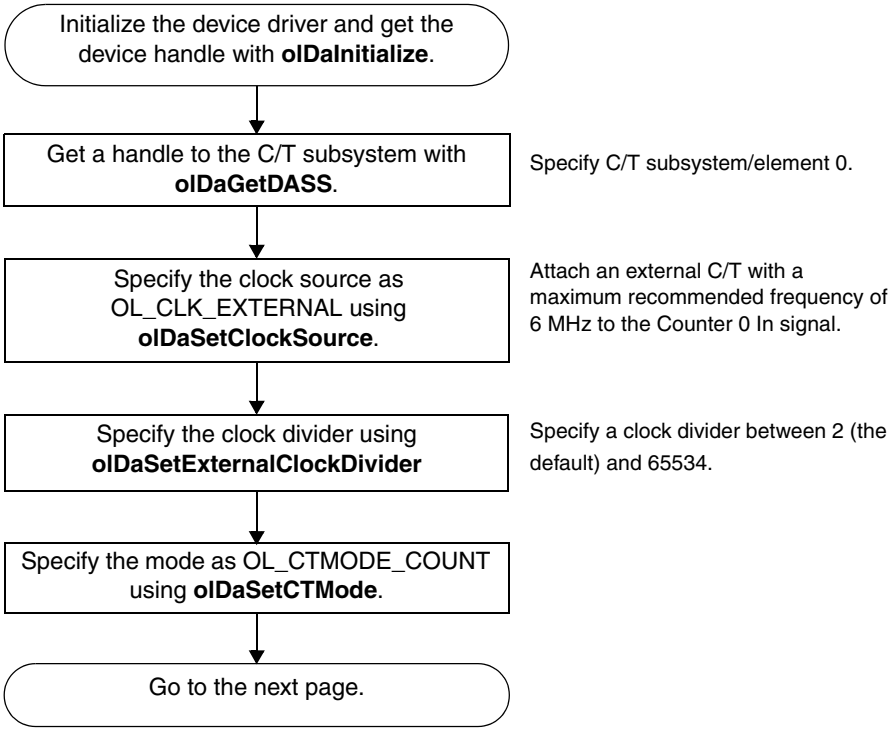

Initialize the device driver and get the device handle with **olDaInitialize**.
Get a handle to the C/T subsystem with **olDaGetDASS**.
Specify C/T subsystem/element 0.
Specify the clock source as OL_CLK_EXTERNAL using **olDaSetClockSource**.
Attach an external C/T with a maximum recommended frequency of 6 MHz to the Counter 0 In signal.
Specify the clock divider using **olDaSetExternalClockDivider**
Specify a clock divider between 2 (the default) and 65534.
Specify the gate type as high-level (OL_GATE_HIGH_LEVEL) or low-level (OL_GATE_LOW_LEVEL) using **olDaSetGateType**
Specify the mode as OL_CTMODE_COUNT using **olDaSetCTMode**.
Configure the subsystem using **olDaConfig**.
Go to the next page.

Event Counting Operations (cont.)

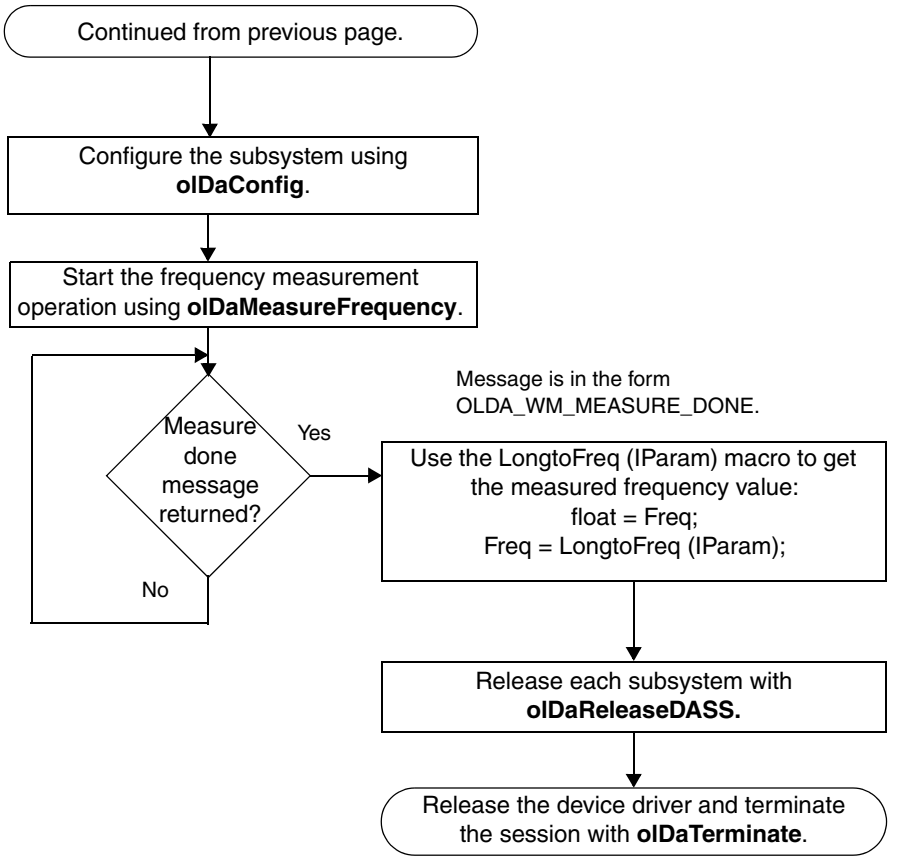

Continued from previous page.
Start the operation using **olDaStart**.
Read the events counted using **olDaReadEvents**.
Get update of events total?
Yes
No
Stop the operation (see page 104).
Release each subsystem with **olDaReleaseDASS.**
Release the device driver and terminate the session with **olDaTerminate**.

Frequency Measurement Operations

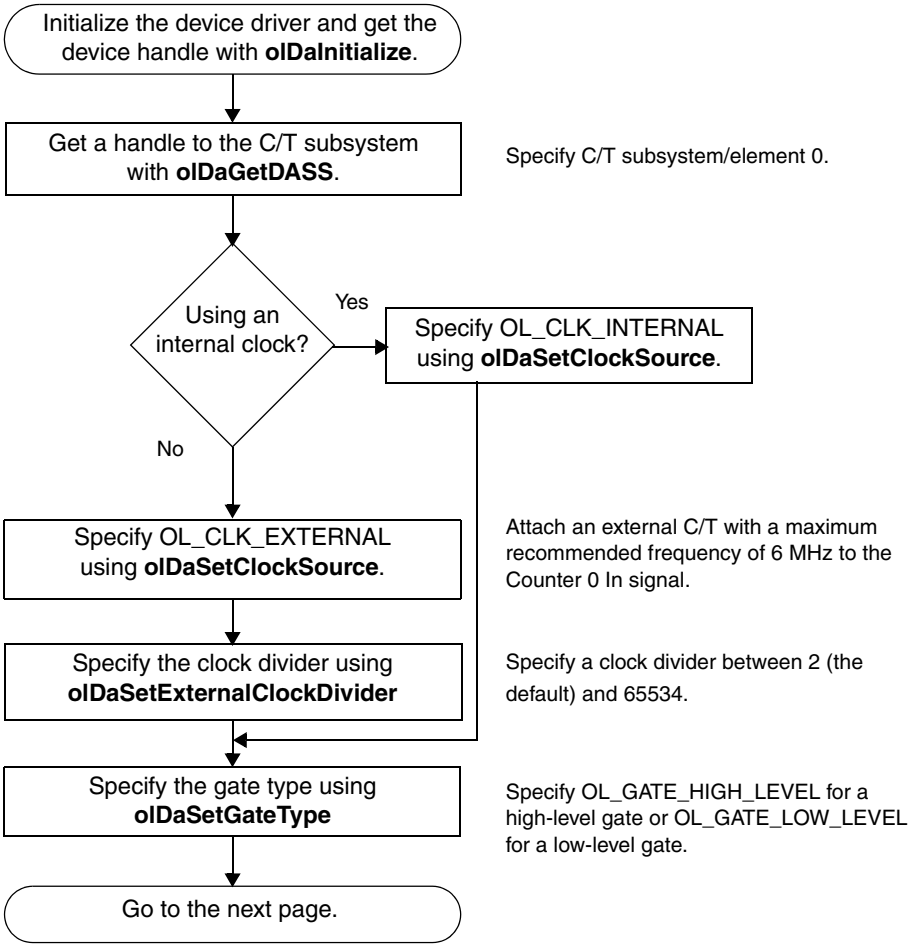
The following flowchart shows the steps required to perform a frequency measurement operation using the Windows timer. If you need more accuracy the Windows timer provides, refer to page 70 of this manual or to your *DataAcq SDK User's Manual* for more information.


Initialize the device driver and get the device handle with **olDaInitialize**.
Get a handle to the C/T subsystem with **olDaGetDASS**.
Specify C/T subsystem/element 0.
Specify the clock source as OL_CLK_EXTERNAL using **olDaSetClockSource**.
Attach an external C/T with a maximum recommended frequency of 6 MHz to the Counter 0 In signal.
Specify the clock divider using **olDaSetExternalClockDivider**
Specify a clock divider between 2 (the default) and 65534.
Specify the mode as OL_CTMODE_COUNT using **olDaSetCTMode**.
Go to the next page.

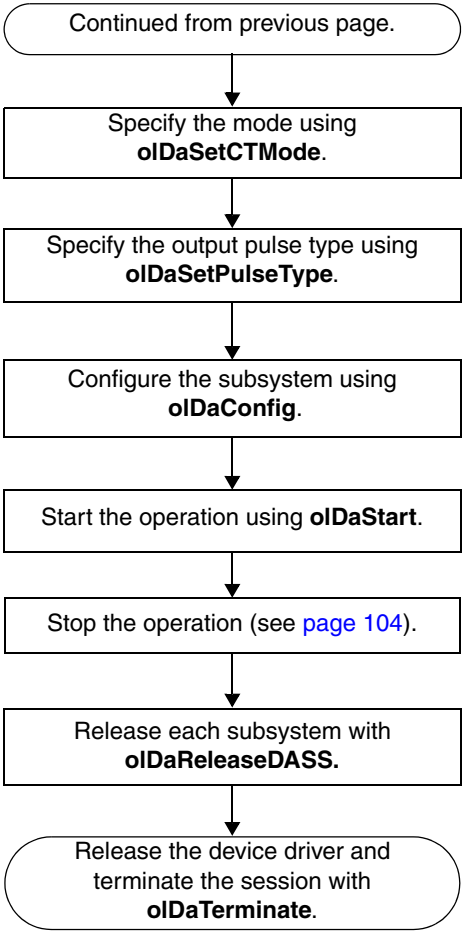
Frequency Measurement Operations (cont.)


Continued from previous page.
Configure the subsystem using **olDaConfig**.
Start the frequency measurement operation using **olDaMeasureFrequency**.
Measure done message returned?
Yes
No
Message is in the form OLDA_WM_MEASURE_DONE.
Use the LongtoFreq (IParam) macro to get the measured frequency value:
float = Freq;
Freq = LongtoFreq (IParam);
Release each subsystem with **olDaReleaseDASS.**
Release the device driver and terminate the session with **olDaTerminate**.

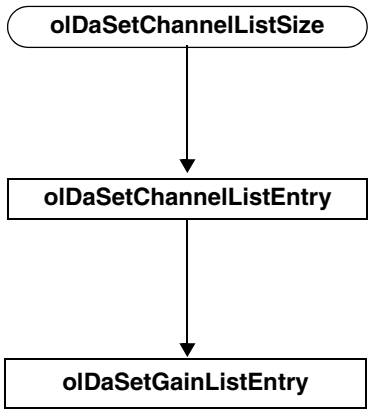
Pulse Output Operations


Initialize the device driver and get the device handle with **olDaInitialize**.
Get a handle to the C/T subsystem with **olDaGetDASS**.
Specify C/T subsystem/element 0.
Using an internal clock?
Yes
Specify OL_CLK_INTERNAL using **olDaSetClockSource**.
No
Specify OL_CLK_EXTERNAL using **olDaSetClockSource**.
Attach an external C/T with a maximum recommended frequency of 6 MHz to the Counter 0 In signal.
Specify the clock divider using **olDaSetExternalClockDivider**
Specify a clock divider between 2 (the default) and 65534.
Specify the gate type using **olDaSetGateType**
Specify OL_GATE_HIGH_LEVEL for a high-level gate or OL_GATE_LOW_LEVEL for a low-level gate.
Go to the next page.

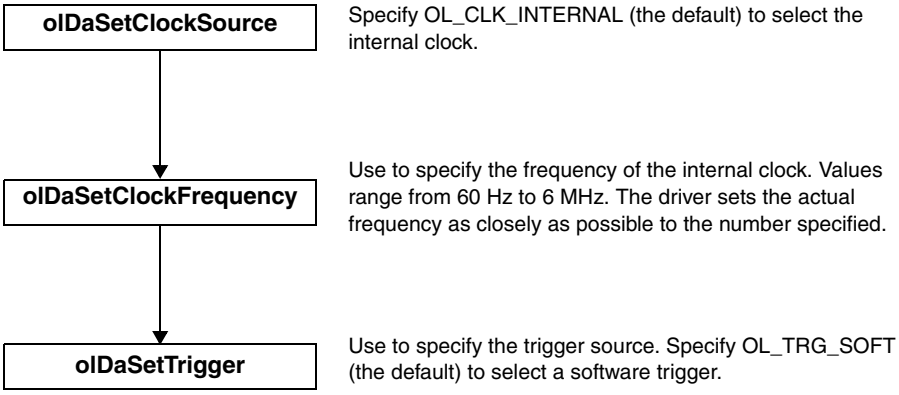
Pulse Output Operations (cont.)


Continued from previous page.
Specify the mode using **olDaSetCTMode**.
Specify OL_CTMODE_RATE for rate generation mode.
Specify the output pulse type using **olDaSetPulseType**.
Must be a high-to-low pulse. The duty cycle is fixed at 50%.
Configure the subsystem using **olDaConfig**.
Start the operation using **olDaStart**.
Stop the operation (see page 104).
Release each subsystem with **olDaReleaseDASS.**
Release the device driver and terminate the session with **olDaTerminate**.

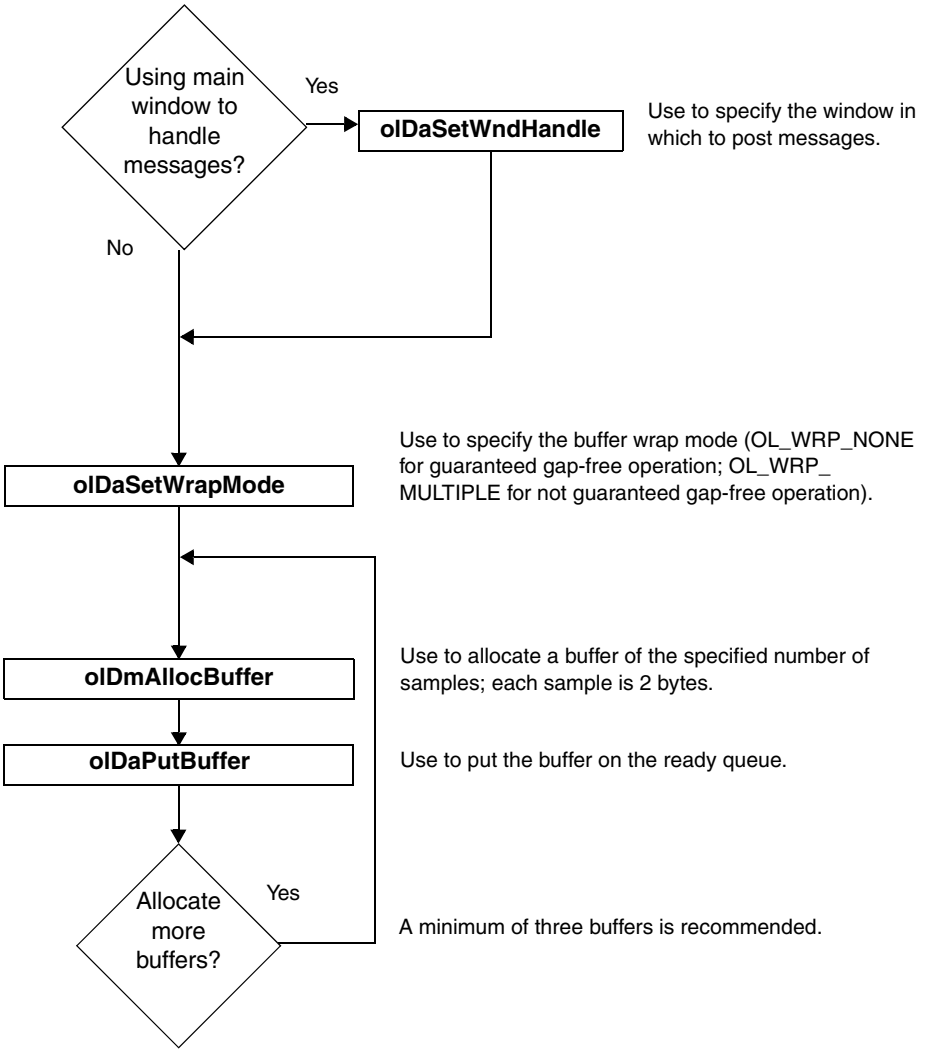
Set Up Channel List and Channel Parameters


olDaSetChannelListSize
Use to specify the size of the analog input channel-gain list (the default is 1).
olDaSetChannelListEntry
Use to set up the analog input channel-gain list. Channels 0 to 5 are available; you can specify up to 6 channels in the channel-gain list.
olDaSetGainListEntry
Specify a gain of 1.

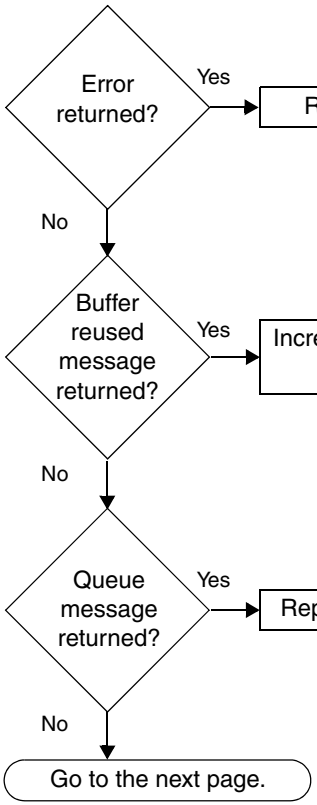
Set Clocks and Triggers


olDaSetClockSource
Specify OL_CLK_INTERNAL (the default) to select the internal clock.
olDaSetClockFrequency
Use to specify the frequency of the internal clock. Values range from 60 Hz to 6 MHz. The driver sets the actual frequency as closely as possible to the number specified.
olDaSetTrigger
Use to specify the trigger source. Specify OL_TRG_SOFT (the default) to select a software trigger.

Set Up A/D Buffering


Using main window to handle messages?
Yes
olDaSetWndHandle
Use to specify the window in which to post messages.
No
olDaSetWrapMode
Use to specify the buffer wrap mode (OL_WRP_NONE for guaranteed gap-free operation; OL_WRP_ MULTIPLE for not guaranteed gap-free operation).
olDmAllocBuffer
Use to allocate a buffer of the specified number of samples; each sample is 2 bytes.
olDaPutBuffer
Use to put the buffer on the ready queue.
Allocate more buffers?
Yes
A minimum of three buffers is recommended.

Deal with A/D Messages and Buffers

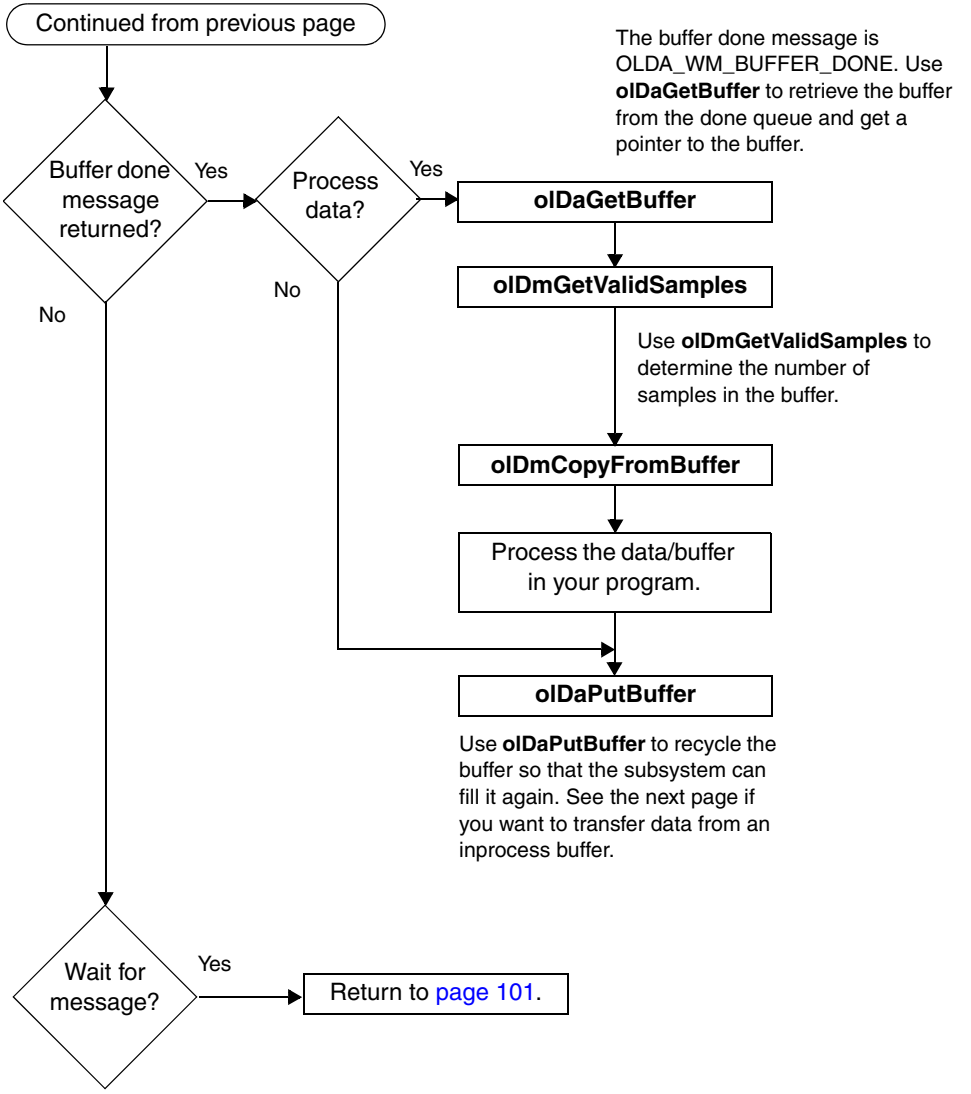


The most likely error message is OLDA_WM_OVERRUN.

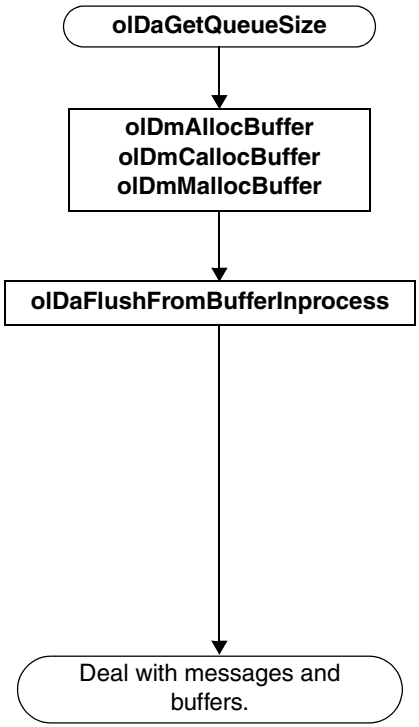
The buffer reused message is OLDA_WM_BUFFER_REUSED.

The queue messages are OLDA_WM_QUEUE_DONE and OLDA_WM_QUEUE_STOPPED. After reporting that the acquisition has stopped, you can clean up the operation (see page 105).

Deal with A/D Messages and Buffers (cont.)


Continued from previous page
Buffer done message returned?
Yes
No
Process data?
Yes
No
The buffer done message is OLDA_WM_BUFFER_DONE. Use **olDaGetBuffer** to retrieve the buffer from the done queue and get a pointer to the buffer.
olDaGetBuffer
olDmGetValidSamples
Use **olDmGetValidSamples** to determine the number of samples in the buffer.
olDmCopyFromBuffer
Process the data/buffer in your program.
olDaPutBuffer
Use **olDaPutBuffer** to recycle the buffer so that the subsystem can fill it again. See the next page if you want to transfer data from an inprocess buffer.
Wait for message?
Yes
Return to page 101.

Transfer Data from an Inprocess Buffer



Use to determine the number of buffers on the inprocess queue (at least one must exist).

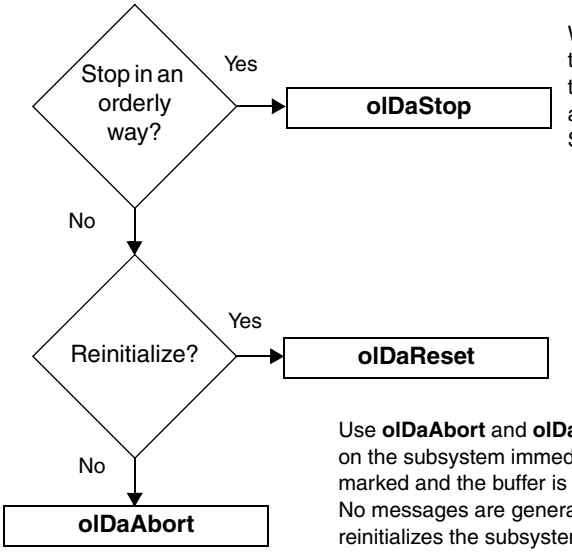
Use to allocate a buffer of the specified number of samples.

Use to copy the data from the inprocess buffer to the allocated buffer for immediate processing.

The buffer into which inprocess data was copied was put onto the done queue by the driver, resulting in an OLDA_WM_BUFFER_DONE message. See page 101 for more information.

When the inprocess buffer has been filled, it too is placed on the done queue and an OLDA_WM_BUFFER_DONE message is posted. However, the number of valid samples is equal to the queue's maximum samples minus what was copied out.

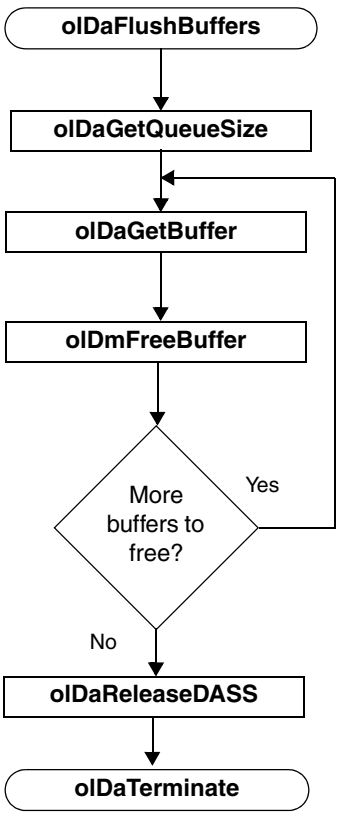
Stop the Operation



Waits until the last sample of the current buffer is filled, then stops. The driver posts a Buffer Done and Queue Stopped message.

Use **olDaAbort** and **olDaReset** to stop the operation on the subsystem immediately; the valid samples are marked and the buffer is placed on the done queue. No messages are generated. In addition, **olDaReset** reinitializes the subsystem to the driver's default state.

Clean Up the Operation



Use to flush all buffers on the ready and/or inprocess queues to the done queue.

Use to determine the number of buffers on the done queue.

Use to retrieve each buffer on the done queue.

Use to free each buffer retrieved from the done queue.

Use to release each subsystem.

Use to release the device driver and terminate the session.

Troubleshooting

General Checklist 108
Technical Support 111
If Your Module Needs Factory Service 112

General Checklist

Should you experience problems using a DT9816 module, do the following:

1. Read all the documentation provided for your product. Make sure that you have added any "Read This First" information to your manual and that you have used this information.
2. Check the ECON CD for any README files and ensure that you have used the latest installation and configuration information available.
3. Check that your system meets the requirements stated in Chapter 2.
4. Check that you have installed your hardware properly using the instructions in Chapter 3.
5. Check that you have installed and configured the device driver properly using the instructions in Chapter 3.
6. Check that you have wired your signals properly using the instructions in Chapter 4.
7. Search the DT Knowledgebase in the Support section of the Data Translation web site (at www.datatranslation.com) for an answer to your problem.
8. Visit the product's page on the Data Translation web site for the latest tips, white papers, product documentation, and software fixes.

If you still experience problems, try using the information in Table 18 to isolate and solve the problem. If you cannot identify the problem, refer to page 109.

Table 18: Troubleshooting Problems

Symptom	Possible Cause	Possible Solution
Module does not respond.	The module configuration is incorrect.	Check the configuration of your device driver; see the instructions in Chapter 3.
	The module is damaged.	Contact Data Translation for technical support; refer to page 111.
Intermittent operation.	Loose connections or vibrations exist.	Check your wiring and tighten any loose connections or cushion vibration sources; see the instructions in Chapter 4.
	The module is overheating.	Check environmental and ambient temperature; consult the module's specifications on page 118 of this manual and the documentation provided by your computer manufacturer for more information.
	Electrical noise exists.	Check your wiring and either provide better shielding or reroute unshielded wiring; see the instructions in Chapter 4.
Device failure error reported.	The module cannot communicate with the Microsoft bus driver or a problem with the bus driver exists.	Check your cabling and wiring and tighten any loose connections; see the instructions in Chapter 4.
	The module was removed while an operation was being performed.	Ensure that your module is properly connected; see the instructions in Chapter 3.

Table 18: Troubleshooting Problems (cont.)

Symptom	Possible Cause	Possible Solution
Data appears to be invalid.	An open connection exists.	Check your wiring and fix any open connections; see the instructions in Chapter 4.
	A transducer is not connected to the channel being read.	Check the transducer connections; see the instructions in Chapter 4.
	The transducer is set up for differential inputs.	Check your wiring and ensure that your transducer is set up for single-ended inputs; see the instructions in Chapter 4.
	The DT9816 module is out of calibration.	The DT9816 module is calibrated at the factory and should not require recalibration. If you want to readjust the calibration of the analog input or analog output circuitry, refer to the instructions on the Data Translation web site (www.datatranslation.com).
Computer does not boot.	The power supply of the computer is too small to handle all the system resources.	Check the power requirements of your system resources and, if needed, get a larger power supply; consult the module's specifications on page 118 of this manual.
USB 2.0 is not recognized.	Your operating system does not have the appropriate Service Pack installed.	Ensure that you load the appropriate Windows Service Pack (version 2 for Windows XP or version 4 for Windows 2000). If you are unsure of whether you are using USB 2.0 or USB 1.1, run the Open Layers Control Panel applet, described in Chapter 3.
	Standby mode is enabled on your PC.	For some PCs, you may need to disable standby mode on your system for proper USB 2.0 operation. Consult Microsoft for more information.

Technical Support

If you have difficulty using a DT9816 module, Data Translation's Technical Support Department is available to provide technical assistance.

To request technical support, go to our web site at http://www.datatranslation.com and click on the Support link.

When requesting technical support, be prepared to provide the following information:

- Your product serial number
- The hardware/software product you need help on
- The version of the ECON CD you are using
- Your contract number, if applicable

If you are located outside the USA, contact your local distributor; see our web site (www.datatranslation.com) for the name and telephone number of your nearest distributor.

If Your Module Needs Factory Service

If your module must be returned to Data Translation, do the following:

1. Record the module's serial number, then contact the Customer Service Department at (508) 481-3700, ext. 1323 (if you are in the USA) and obtain a Return Material Authorization (RMA).

   If you are located outside the USA, call your local distributor for authorization and shipping instructions. The name and telephone number of your nearest distributor are listed on Data Translation's web site. All return shipments to Data Translation must be marked with the correct RMA number to ensure proper processing.

2. Using the original packing materials, if available, package the module as follows:

   – Wrap the module in an electrically conductive plastic material. Handle with ground protection. A static discharge can destroy components on the module.

   – Place in a secure shipping container.

3. Return the module to the following address, making sure the RMA number is visible on the outside of the box.

   Customer Service Dept.
   Data Translation, Inc.
   100 Locke Drive
   Marlboro, MA 01752-1192

Specifications

Table 19 lists the specifications for the A/D subsystem on the DT9816 module.

Table 19: A/D Subsystem Specifications

Feature	DT9816 Specifications
Number of analog input channels	6 single-ended
Number of gains	2 (1, 2)
Resolution	16-bit
Data encoding	offset binary
System accuracy, to % of FSR (Averaged over 50 readings)	 ±0.08%
Range	±5 V, ±10 V
Nonlinearity	0.015 %
Differential nonlinearity	0.003 %
Inherent quantizing error	±½ LSB
Drift Zero: Gain:	 ±25 µV/°C ±50 ppm/°C
Differential linearity:	monotonic to 14 bits
Input impedance[a] Off channel: On channel:	 — 10 MΩ, 10 pf
Input bias current	±10 nA
Maximum input voltage (without damage) Power on: Power off:	 ±35 V ±20 V

Table 19: A/D Subsystem Specifications (cont.)

Feature	DT9816 Specifications
A/D conversion time	4 µs (DT9816-A) 8 µs (DT9816)
Channel acquisition time (±½ LSB)	1 µs
Sample-and-hold Aperture uncertainty: Aperture delay: Aperture match: Gain match: Zero match:	 1 ns 35 ns 5 ns 0.05% ±3.0 mV
Throughput	50 kHz per channel (DT9816) 150 kHz per channel (DT9816-A)
ESD protection (per spec) Arc: Contact:	 8 kV 4 kV
Reference	2.5 V
Monotonicity	Yes

a. Very high input impedance minimizes any source error.

Table 20 lists the specifications for the digital input (DIN) and digital output (DOUT) subsystems on the DT9816 module.

Table 20: DIN/DOUT Subsystem Specifications

Feature	DT9816 Specifications
Number of digital I/O lines	16 (8 each; dedicated)
Number of ports	2, 8-bit
Input termination	Series 1 kΩ; Series 33.2 Ω
Logic family	TTL
Logic sense	Positive true
Inputs Input type: Input logic load: High input voltage: Low input voltage: Low input current:	 Level sensitive 1 TTL Load 2.4 V min 0.8 V max -0.4 mA max
Outputs High output: Low output: High output current (source): Low output current (sink):	 2.8 V min 0.6 V max 4.5 mA 10 mA
Software I/O selectable	Yes
ESD protection (per spec) Arc: Contact:	 8 kV 4 kV

Table 21 lists the specifications for the C/T subsystem on the DT9816 module.

Table 21: C/T Subsystem Specifications

Feature	Specifications
Number of counter/timers	1
Counter/timer modes	Event counting, frequency measurement, rate generation
Resolution	16-bit
Minimum pulse width: (minimum amount of time it takes a C/T to recognize an input pulse)	25 ns
Logic family	TTL
Inputs Input logic load: High input voltage: Low input voltage: Low input current:	Level sensitive 1 TTL Load 2.4 V min 0.8 V max -0.4 mA max
Outputs High output: Low output: High output current (source): Low output current (sink):	 2.8 V min 0.6 V max 2 mA 12 mA
ESD protection (per spec) Arc: Contact:	 8 kV 4 kV
Internal clock frequency	60 Hz to 6 MHz
External clock divider	2 to 65534

Table 22 lists the power, physical, and environmental specifications for the DT9816 module.

Table 22: Power, Physical, and Environmental Specifications

Feature	DT9816 Specifications
Power, +5 V Enumeration Operation	<100 mA <250 mA
Physical Dimensions (board): Dimensions (box with screw terminals and feet): Weight (board): Weight (box with screw terminals and feet):	 100 mm (L) x 100 mm (W) x 15.5 mm (H) 107.7 mm (L) x 100 mm (W) x 33.5 mm (H) 65.8 g 138.8 g
Environmental Operating temperature range: Storage temperature range: Relative humidity:	 0 to 55° C -40 to 85° C to 95% non-condensing

Screw Terminal Assignments

Table 23 lists the screw terminal assignments for the DT9816 module.

Table 23: DT9816 Screw Terminal Assignments

Screw Terminal	Signal	Screw Terminal	Signal
20	USB +5 V Out	40	Ext Trigger
19	Ground	39	Ext Clock
18	Counter 0 In	38	Ground
17	Counter 0 Out	37	Digital Output 7
16	Counter 0 Gate	36	Digital Output 6
15	Ground	35	Digital Output 5
14	Reserved	34	Digital Output 4
13	Reserved	33	Digital Output 3
12	Reserved	32	Digital Output 2
11	Reserved	31	Digital Output 1
10	2.5 V Reference	30	Digital Output 0
9	Analog Ground	29	Ground
8	Reserved	28	Digital Input 7
7	Reserved	27	Digital Input 6
6	Analog Input CH5	26	Digital Input 5
5	Analog Input CH4	25	Digital Input 4
4	Analog Input CH3	24	Digital Input 3
3	Analog Input CH2	23	Digital Input 2
2	Analog Input CH1	22	Digital Input 1
1	Analog Input CH0	21	Digital Input 0

Reading from or Writing to the Digital Registers

If you want to read the value of the digital input lines or write to the digital output lines quickly and do not want to use DT-Open Layers to do this, you can use the following API functions:

- **olReadReg**, described on page 123
- **olWriteReg**, described on page 125

These functions access the registers of the module directly.

olReadReg

Syntax

```
ECODE olReadReg (
    HDEV hDev,
    ULNG Address,
    PULNG pData);
```

Include File

oldadefs.h
oldaapi.h

Description

Reads data directly from the digital registers of the module.

Parameters

Name: hDev

Description: A variable of type HDEV that specifies the handle to the device.

Name: Address

Description: An unsigned long variable that specifies the base address of the desired register.

Values are as follows:

- **DIO_PORT_CONFIG** –Port configuration register.
- **DIO_PORT_DATA** –Port data register.

Name:	pData
Description:	A pointer to a unsigned long variable in which the data from the specified register is returned. Values can range from 0 to 4,294,967,295. If DIO_PORT_CONFIG is specified for *Address*, the value of the variable pointed to by *pData* is the bit mask that specifies the configuration of the digital I/O lines, where bits that have "0" values are input lines and bits that have "1" values are output lines. If DIO_PORT_Data is specified for *Address*, the value of the variable pointed to by *pData* represents the state of the digital input lines.
Notes	The DT9816 module has 8 digital input and 8 digital output lines (0 to 7 each).
Return Values	Possible return values are as follows:
OLBADRANGE	The value is out of range for the device.
OLNOTSUPPORTED	Request not supported by subsystem.
OLBADDEVHANDLE	Illegal device handle specified.

olWriteReg

Syntax

```
ECODE olWriteReg (
    HDEV hDev,
    ULNG Address,
    ULNG DataVal);
```

Include File

oldadefs.h
oldaapi.h

Description

Writes values directly to the digital registers of the module.

Parameters

Name: hDev

Description: A variable of type HDEV that specifies the handle to the device.

Name: Address

Description: An unsigned long variable that specifies the base address of the hardware register to write to.

Values are as follows:

- **DIO_PORT_CONFIG** –Port configuration register.
- **DIO_PORT_DATA** –Port data register.

Name:	DataVal
Description:	An unsigned long variable that contains the digital output value to write the specified register. Values can range between 0 and 4,294,967,295. If DIO_PORT_CONFIG is specified for *Address*, the value specified for *DataVal* is the bit mask that configures the digital I/O lines for input (0) or output (1). If DIO_PORT_Data is specified for *Address*, the value specified for *DataVal* is the value that is written to the configured digital output lines.
Notes	You can configure 8 digital input and 8 digital output lines for the DT9816 module.
Return Values	Possible return values are as follows:
OLBADRANGE	The value is out of range for the device.
OLNOTSUPPORTED	Request not supported by subsystem.
OLBADDEVHANDLE	Illegal device handle specified.

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